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SIMPOSIO INTERNACIONAL DE ACRIDIOLOGIA
SEMINAR – STUDY CONFERENCE

RECIENTES AVANCES Y NUEVAS TENDENCIAS EN ACRIDIOLOGIA
RECENT ADVANCES AND NEW DIRECTION IN ACRIDOLOGY

San Martín de los Andes – Argentina, 6–11 Diciembre 1976

La SOCIEDAD ENTOMOLOGICA ARGENTINA cede con sumo placer la edición del Volumen 36 de su Revista, para la publicación de las contribuciones que se presentaran en oportunidad de la realización del Simposio Internacional de Acridiología, auspiciado por el Consejo Nacional de Investigaciones Científicas y Técnicas y la National Science Foundation en el marco del Programa de Cooperación Científica entre la República Argentina y los Estados Unidos de Norte América, en San Martín de los Andes, Neuquén, Argentina.

A su vez y por decisión unánime, en esta oportunidad, brinda su órgano de difusión científica a la flamante SOCIEDAD PANAMERICANA DE ACRIDIOLOGIA (PANAMERICAN ACRIDOLOGICAL SOCIETY) fundada en oportunidad de la realización del referido Simposio, en el entendimiento de que la misma ha de permitir nuclear a todos aquellos entomólogos puros y aplicados que, como lo enuncian los principios de su creación, se dediquen al estudio de la Acridiología del Nuevo Mundo.

Nuestra Sociedad es conciente de la enorme tarea que es necesario desarrollar en este campo en el Nuevo Mundo y en especial en la Neotrópica y es por ello que desea y hace votos, para que esta recién creada Sociedad intente promover una amplia cooperación entre todos aquéllos que tanto en forma individual como Institucional se dedican a esta disciplina, no sólo por su interés puramente científico sino también por el aplicado.

La necesidad de un creciente intercambio de información y la intensificación de programas de investigación coordinados ha llevado a la SEA a recibir con júbilo esta iniciativa, asi como brindar las páginas de su Revista para difundir los interesantes trabajos referidos a la acridiofauna americana dados a conocer en esa oportunidad.

Entendemos que la creación de Sociedades que nucleen a especialistas en temas definidos no atomizan a la comunidad entomológica, sino que por el contrario aseguran una mayor comunicación y una menor pérdida de esfuerzos, ya que tienen la virtud de concentrar en ellas a los estudiosos de fracciones muy específicas del mundo entomológico, sin que ello vaya en desmedro de entidades madre como la nuestra.

Una vez más hacemos votos para un constante crecimiento de la flamante Sociedad Panamericana de Acridiología y nos sentimos honrados de poder serles útiles como en esta oportunidad.

SOCIEDAD ENTOMOLOGICA ARGENTINA
Diciembre de 1977

SOCIEDAD PANAMERICANA DE ACRIDIOLOGIA
PAN AMERICAN ACRIDOLOGICAL SOCIETY

Con motivo de la realización del Simposio Internacional de Acridiología en San Martín de los Andes, bajo los auspicios del Programa de Cooperación Científica entre los Estados Unidos de Norte América y la República Argentina (National Science Foundation y Consejo Nacional de Investigaciones Científicas y Técnicas) en diciembre del año 1976, se crea la SOCIEDAD PANAMERICANA DE ACRIDIOLOGIA, designándose un Comité Organizador integrado por: S. K. Gangwere (U. S. A.) como Presidente, I. J. Cantrall (U. S. A.) como Secretario, complementado por los siguientes miembros: R. A. Ronderos (Argentina), C. S. Carbonell (Uruguay), L. Esquivel (Argentina), A. Ferreira (Brasil), J. E. Henry (U. S. A.), N. D. Jago (Inglaterra), H. R. Roberts (U. S. A.) y V. R. Vickery (Canadá), quienes quedan encargados de redactar los estatutos de la Sociedad y convocar a la elección de la Mesa Directiva definitiva.

Los Estatutos y Reglamento son aprobados en 1977, constituyéndose la Mesa Directiva por elección de todos los Miembros habilitados el 14 de diciembre del mismo año, la que está integrada por el término 1977–1979 de la siguiente manera: Presidente S. K. Gangwere; Presidente Electo: R. A. Ronderos; Representante por Norte América: J. D. Henry; Representante por Centro América: C. Marquez Mayaudón; Representante por Sudamérica: C. S. Carbonell; Secretario Ejecutivo: I. J. Cantrall y Co–Editores: M. J. Tyrkus y N. Lafuente Indo.

Los propósitos fundamentales de esta Sociedad son los de facilitar la comunicación entre aquellas personas interesadas y en relación con la Acridiología del Nuevo Mundo a fin de propender a la realización de investigaciones en cooperación e intercambio de información en estos temas entre los paises del Continente, contando en la actualidad con 130 Miembros, habiendo sido designados como Honorarios los Dres. D. K. McE. Kevan del Canadá, T. H. Hubbell de los Estados Unidos, J. Liebermann de la Argentina y M. Descamps de Francia.

La próxima Asamblea de esta Sociedad se realizará en Bozeman, Montana, U. S. A., entre el 23 de julio y 3 de agosto de 1979, oportunidad en que se desarrollará el Segundo Simposio Internacional de la especialidad, siendo su organizador el Dr. J. E. Henry del USDA Rangeland Insect Laboratory, Montana State University, Bozeman, Montana 59715.

Toda información adicional referida a esta Sociedad puede ser requerida al Dr. I. J. Cantrall, Museum of Zoology, University of Michigan, Ann Arbor, Michigan 48104, U.S.A.

THE AMERICAN PYRGOMORPHIDAE (ORTHOPTERA)

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INTRODUCTION

The Pyrgomorphidae constitute a well-defined family of 145 genera and rather more than 400 species of "bush-hoppers" (a term preferable to "grasshoppers" as the majority are not associated with grass), most of which are tropical or subtropical (Kevan, 1977). Rather few are found in temperate regions, but they occur there in both northern and (in the Old World only) southern hemispheres. Two or three species can withstand fairly rigorous winter conditions, for which, however, they do not appear to be specially adapted. Pyrgomorphidae have virtually no fossil record (one rather uninformative, and possibly dubious specimen from the Miocene of central Europe), but it is believed that not many living species remain to be discovered.

ZOOGEOGRAPHY AND PHYLOGENY

The Pyrgomorphidae are clearly a "Gondwanaland" assemblage, and their epicentre of evolution may be postulated to have been "Lemurian", for they show their greatest diversity, as judged by the number of tribes, in the Southeast Asian area and in Madagascar. The region of major speciation at present, however, seems to have shifted westwards, for the greatest number of genera and species are now found in Madagascar and particularly in Africa. The probability of a "Lemurian" origin for the Pyrgomorphidae finds some support in the occurrence, only in the Mascareigne Islands of the Indian Ocean, of the anomalous, monogeneric, relict subfamily Pyrgacridinae (Kevan, *in* Eades and Kevan, 1975).

Although the Pyrgomorphidae represent an old family, their presence in Africa, or at least the more northerly and westerly parts of that continent, is porbably more recent than the Cretaceous, for there appears to be little in common between the Pyrgomorphidae of Africa and those of South America. That is, there seems to have been no common origin for the faunas of the two continents prior to their separation. It would, indeed, be very accommodating if the isolated, monotypic, West African genus *Chapmanacris* could be shown to be in any way closely related to the geographically isolated (?), monotypic genus *Algete* from NE Brazil, but it cannot. The two genera differ radically, not only in external morphology, but also in the form of their concealed copulatory structures (Kevan *et al.*, 1971, 1974). *Chapmanacris* is an anomalous genus, placed in its own tribe and superficially resembling Oriental and Malagasy Orthacridini and other cylindrical, apterous and micropterous tribes, including the Mexican Ichthyotettigini, to none of which it appears to be particularly close taxonomically. *Algete*, on the other hand, is clearly derived from the same stock as the few other South

American pyrgomorphid genera (tribe Omurini), the least specialized of which, in terms of gross external morphology (though not in its phallic structures), is *Minorissa,* which is also the most northerly and westerly member of its tribe. This genus is superficially very similar in appearance to the widespread Old World (predominately Oriental) genus *Atractomorpha,* to which, nevertheless, it bears no close relationship, though there may be some remote connection. It is also very similar externally to the monotypic Malagasy genus *Schulthessia,* to which it is not closely related either (Kevan *et al.,* 1974). The relationships of the Omurini seem, in fact, closest to the Mexican and Central American Sphenariini (Sphenariina), which are, however, quite different in appearance (Kevan *et al.,* 1974).

Convergence in external morphology is very common in the Pyrgomorphidae, and the four American tribes, each with its own characteristic general appearance, all have Old World counterparts among unrelated tribes. Thus, as already noted, the Omurini of South America (see Kevan, 1966) have their unrelated Eastern Hemisphere counterparts, the Atractomorphini and Schulthessiini (see Kevan, 1961). Whilst all three tribes include narrowly fusiform, fully alate genera with acutely conical heads *(Minorissa, Atractomorpha, Schulthessia),* it is of interest to note that both Omurini and Atractomorphini also include apterous forms with depressed bodies *(Algete* and *Omura; Occidentosphena,* the last differing from the others in being much less elongate—see Kevan *et al.,* 1974); there also appears to be a genus of Schulthessiini with somewhat reduced wings *(Buyssoniella),* although the unique holotype of the only species has been lost (Kevan *et al., op. cit.).* Both genera of American Sphenariini (from Central America and Mexico) belong to a distinct subtribe (Sphenariina) which has three related subtribes in the Old World, but there are also convergent members of other unrelated tribes, notably the Parasphenina of the tribe Pyrgomorphini, and particularly the genus *Chirindites,* which is not only very similar in size, form and variation in colour, but which lives in similar situations and even exhibits (like the American *Sphenarium* and *Prosphena)* an unusual phenomenon whereby the males are often as large as or even larger than females. The type species of *Parasphena* was indeed first described in *Sphenarium.* Some larger specimens of *Pyrgomorphella (Phyrgomorphina)* are also rather reminiscent of less robust Sphenariini.

The other two American tribes (see Kevan *et al.,* 1964) are both exclusively Mexican, the one (Ichthiacridini) having a slender, subcylindrical shape and, usually, minute scale-like vestigial tegmina; the other (Ichthyotettigini) being usually even more cylindrical, with generally blunter heads, quite apterous and often with complex male abdominal terminalia. Perhaps the closest Old World parallel of these two tribes would be a comparable pair from Madagascar: the Sagittacridini and the Geloiini (Kevan *et al.,* 1970). As already noted, the West African Chapmanacridini and the Malagasy and SE Asiatic Orthacridini (as well as some other groups) are also rather similar in overall appearance, particularly to Ichthyotettigini. Whilst the Chapmanacridini appear to be unrelated to any of the others, it has been suggested that the Ichthiacridini may be remotely related to the Orthacridini (see below) and that the Ichthyotettigini may, in turn, have been derived from something like the former tribe (Kevan *et al.,* 1970).

American Pyrgomorphidae seem to fall into two distinct groups, the Sphenarini-Omurini group and the Ichthiacridini-Ichthyotettigini group. The former has connections with other Sphenariini in the Orient (the closest relatives are the Mekongianina of SW China, SE Tibet and NE India). The latter group probably has less in common with Old World forms, but there are certain features in addition to body-form which suggest some remote connection with the Orthacridini. That tribe and the Ichthiacridini both have, for example, the "aedeagal sclerites" partially divided apically (Kevan *et al.,* 1971), or, more correctly (Eades and Kevan, 1975), they both have indications of true aedeagal sclerites at the apices of the gonopore processes.

Such indications as exist all point to the American Pyrgomorphidae being incursors into the New World, derived from Asiactic ancestors, presumably entering North America by an ancient, comparatively warm, Beringian connection, such as is invoked to explain the occurrence of other groups of organisms common to more southerly region of Asia and North America, but which are currently absent from cooler, more northerly latitudes. It would also seem that incursions from Asia occurred at least twice. The earlier of the

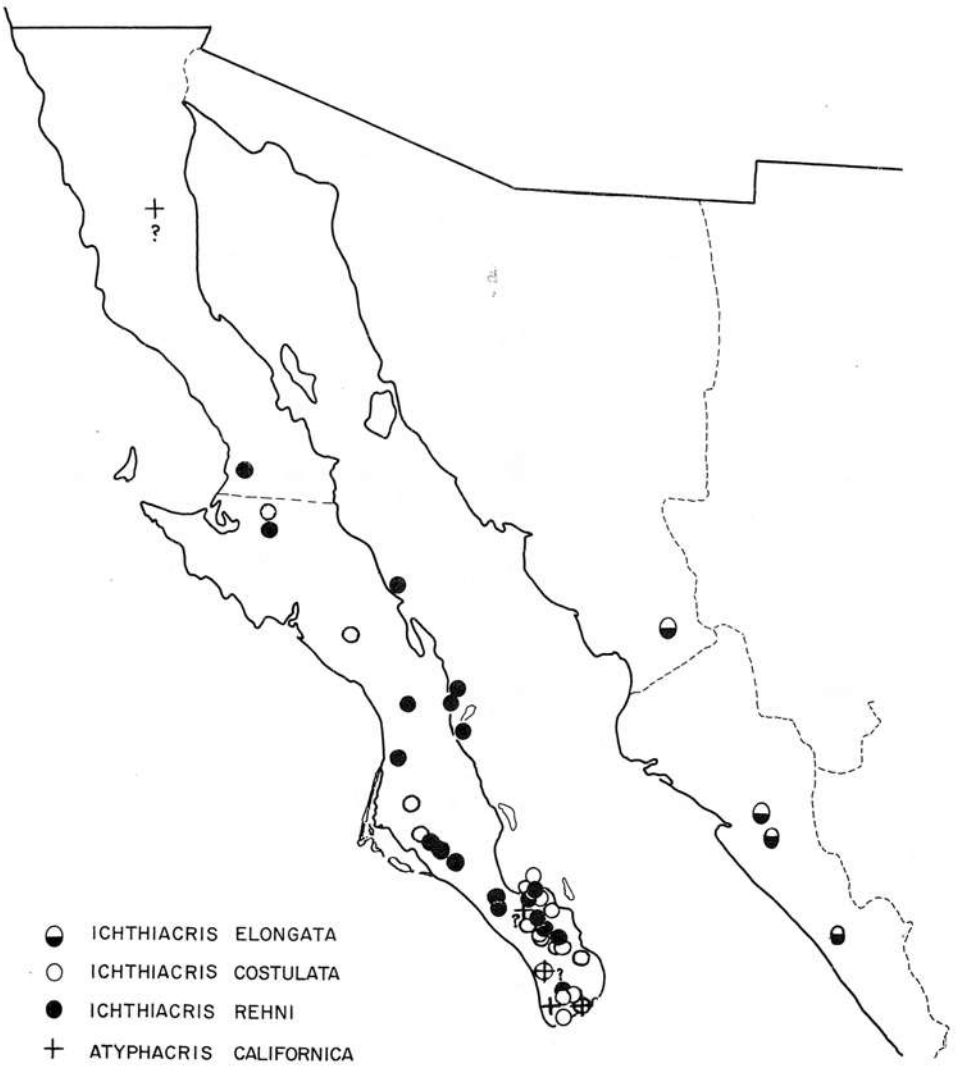

Fig. 1. Known distribution of Ichthiacridini in N.W. Mexico

two was possibly "sphenariine", including some fully winges forms. In this connection it may be noted that the most primitive sphenariine to-day is *Rubellia nigrosignata* Stal of Madagascar, which is brachypterous, rather than micropterous, not infrequently producing fully winged forms; and the rare *Sphenexia fusiformis* Karsch of Tanzania may conceivably prove to be similar in this respect. Although all other Sphenariini, including American ones, would now seem to have reduced their wings to the point of no return, surprising reversions to a fully winged state nevertheless occur in certain micropterous Pyrgomorphidae. Perhaps the most striking example of this is the Australian *Psedna nana* Rehn f. *macroptera* Kevan *et al.* (see Key, 1972).

The reason for suggesting a winged condition for some at least of the earlier "sphenariine" invaders is that the exclusively South American Omurini and the exclusively Mexican and Central American Sphenariina may have had a common ancestor (Kevan *et al.*, 1974), and yet the former group contains the only fully winged and the

only short-winged[1] American pyrgomorphids, *Minorissa pustulata* Walker and *Deraspiella volxemi* (Bolívar), respectively. The ancestors of the Omurini, having entered South American from North America, became isolated and scattered quite widely throughout the tropics but were unable to cross the Cordillera. Having become established in their new continent they followed the general inherent tendency among Pyrgomorphidae to lose their wings, for the other two genera, *Omura* and *Algete,* are apterous. It is a matter for comment that, despite the widespread predominance of flightless forms amongst Pyrgomorphidae, the two alate species mentioned are the only ones in the entire American fauna that have more than minute scale-like vestiges of wings.

That the ichthiacridine-ichthiotettigine ancestors entered America later than the others is purely conjectural, based on the fact they are the most northerly of the American Pyrgomorphidae. Contrary to this surmise, it could be that they were the earlier to arrive, for their relationships with Old World tribes are more distant in terms of both morphological affinity and geography. They are also of very low vagility, for none of them, nor any of their possible Old World relatives, has more than the minutest vestiges of wings. As with the sphenariine-omurine group, one tribe is northern and the other southern. Both are found entirely within the confines of Mexico, but they do not overlap to more than a small degree, the limits of their respective distributions being more or less contiguous. The less specialized tribe, the Ichthiacridini, which retains both traces of true aedegal sclerites and, in almost all, vestigial tegmen-scales, have remained behind in the more northerly parts of the country, and, in general, in lower, more arid regions. They may be said to be basically Sonoran. It is interesting that more than half of the few known species are isolated in Baja California. The Ichthyotettigini, which do not retain the characters mentioned, which have highly specialized male copulatory structures, and which may be derived from ichthiacridine-like ancestors, are all more southerly and incline to somewhat higher elevations and/or less arid situations. Of this tribe, the most highly specialized (*Piscacris* and *Pyrgotettix)* are, in general, the most southerly.

Before leaving the matter of the origins of the American Pyrgomorphidae, brief reference should perhaps be made of the exclusively South American family Tristiridae[2], which, as discussed at some length by Eades and Kevan (1975), has apparently some affinity to the Pyrgomorphidae. By contrast whith the poor representation of the latter family in South America, no less than 16 (and possibly more) genera of Tristiridae are known. Furthermore they are almost exclusively Patagonian or Cordilleran; precisely what the Pyrgomorphidae are not. They are presumably descended from ancient "austral" stock, which also gave rise to the southern African Lathiceridae and Lentulidae (the latter reaching East Africa) as well as to the Pyrgomorphidae. That the Pyrgomorphidae and Tristiridae (and the other two families) appear to be distantly related (Eades and Kevan, 1975) does not mean that the South American Pyrgomorphidae have any immediate common ancestry with the Tristiridae, because the latter are southern and the former (so far as the Americas are concerned) northern in origins.

AMERICAN GENERA AND SPECIES

As indicated in Table I, there are only 14 American genera of Pyrgomorphidae, many of them monotypic, with but four monotypic genera in South America. With the four species included in these, there are only 22 known species, 17 out of the 18 additional species being Mexican, and, of these, one is too poorly known to describe and

[1]Not strictly brachypterous as the tegmina are of moderate lengt.

2 Should *Aspidophyma americana* Bolívar eventually prove to belong to the same family, which it may well do, the family name would have to be changed to Aspidophymidae, for the oldest available group name would then be Aspidophymae Bolívar, 1884, which would take precedence over "Tristiri" Rehn, 1906, and "Chilacrinae" Liebermann, 1943 (Eades and Kevan, 1975). The earliest used "Group" name has priority in such cases, not the earliest named genus, as was used by Dirsh (1975).

two are new, both in the genus *Sphenarium*. Two include two subspecies each. One of the Mexican species extends into Guatemala; the non-Mexican species *(Prosphena scudderi* Bolívar) occurs from Guatemala to Costa Rica, but is not yet known from Panama.

With the exception of *Sphenarium,* all the Mexican and central American species have been reviewed by Kevan *et al.* (1964), and all the known South American species by Kevan (1966). Kevan *et al.* (1971) list all the genera and species of Ichthiacridini and Ichtyotettigini, and then later (Kevan, *et al.,* 1974) do the same for the Omurini and Sphenariini, the last including preliminary synonymies in *Sphenarium.* Full bibliographic references to all species are given by Kevan *(in press).* Revised information on distribution accompanies this contribution (Figs. 1-6; Table I; Appendix I) and one species of *Ichthiacris* has fallen into synonymy (Appendix I). *Sphenarium* has now been revised (Boyle, unpublished 1974; Kevan & Boyle, *in preparation)* and some of the results are included here: distribution maps (Figs. 3, 4), a further synonymy (Table I), and preliminary diagnoses of two new species (Appendix II).

The extreme variability of most members of the genus *Sphenarium,* both in size and coloration, as well as in other morphological features, has bedevilled its taxonomy for a century. A study of the concealed copulatory structures, however, has now made possible a reasonable solution to the major taxonomic problems, and different species and subspecies are now shown to have fairly definite zoogeographical distribution patterns (Figs. 3, 4). As noted by Kevan (1973), however, the variation is such that, in some species at least, the external morphology and coloration of different species in the same areas tend to converge. This is particularly marked, for example, in the case of the new

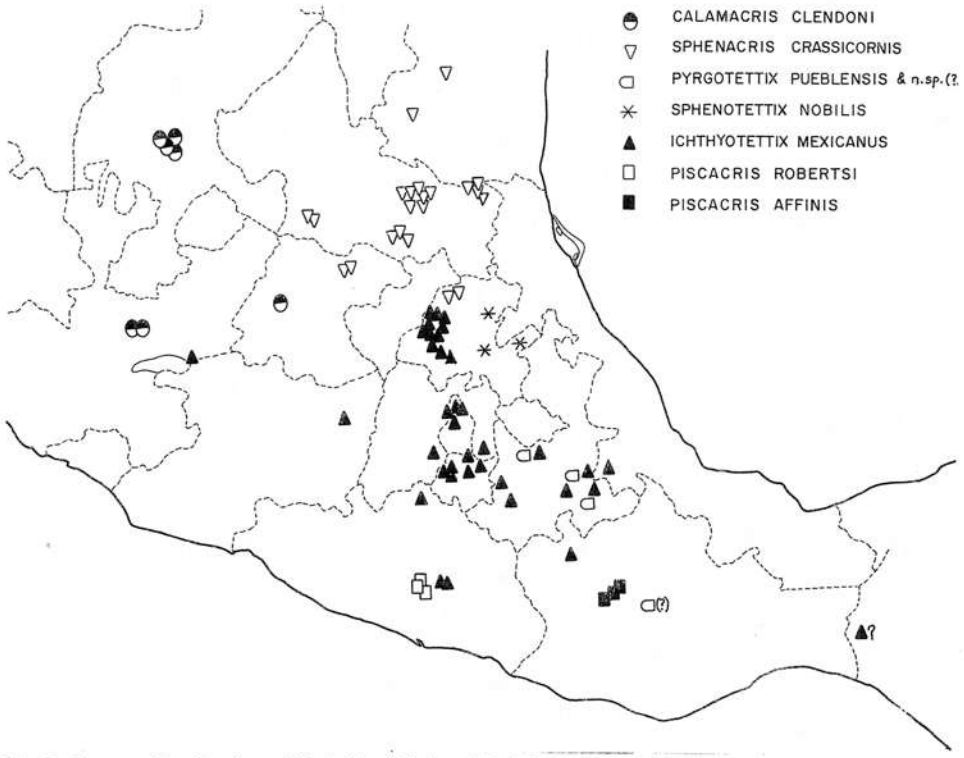

Fig. 2. Known distribution of Ichthiacridini and Ichthyotettigini in central and southern Mexico (After Kevan *et al.,* 1964, slightly modified).

species, *S. variabile,* which is sometimes virtually impossible to distinguish externally from *S. purpurascens* Charpentier in the same region. In fact, one can almost say that the more closely associated the two sympatric species, the more alike they appear. Their phallic structures readily distinguish them, but it would seem that similar ecological pressures

result in almost identical phenotypes in the two species. How much of the similarity is due to environmental and how much to genetic effects would prove to be an interesting field of study. A somewhat contrary phenomenon has also shown itself recently in *S. mexicanum* Saussure, a species of enormous size differences and colour range, from which it has been found impossible to distinguish *S. histrio* Gerstaecker beyond the subspecies level. Yet a population of undoubted *histrio* has been found in the Vera Cruz coastal region virtually surrounded by *S. mexicanum mexicanum.* In this case a much more

Fig. 3. Known distribution of *Sphenarium* in Mexico (1) and in Guatemala.

detailed knowledge of the exact geographical distribution is needed in order to ascertain if there is, or might recently have been, any continuance between the isolated and the main *histrio* populations (see Fig. 3). Or is there here perhaps an example of local topotypic subspeciation? Insufficient data are yet available to answer this question, but much could undoubtedly be learnt about the principles of biological variability by a detailed study of *Sphenarium.*

Bibliographic references to all aspects of the American Pyrgomorphidae are given by Kevan (1977), but some of the more significant points related to other than systematic matters may be noted here.

MORPHOLOGY

Most of what is known of the morphology and anatomy of American Pyrgomorphidae relates to their copulatory structures and will be found in the works of Marquez Mayaudon (1962) for *Sphenarium,* Kevan *et al.* (1964) for Ichthiacridini, Ichthyotettigini, and *Prosphena* Kevan (1966) for Omurini; and Kevan *et al.* (1971, 1974)

for each genus. The last mentioned works also review the previous literature on the genitalia of the relevant tribes, so that there is no need to repeat the references here. The only subsequent literature reference to this aspect of morphology is given by Dirsh (1975) for *Omura;* nothing new is added to what was previously known. Boyle (1974) and Kevan and Boyle *(in preparation)* give details of the concealed copulatory structures of the species of *Sphenarium,* including their variation.

With regard to other aspects of morphology, the earliest reference to a particular morphological feature in American Pyrgomorphidae is that of Graber (1876), who notes the presence, in *Sphenarium,* of an abdominal tympanum despite the fact that the genus is mute and micropterous. The tympana of *Omura* and *Sphenarium mexicanum* are considered by Knetsch (1939) and referred to by Mason (1969). Banerjee and Kevan (1962) also refer briefly to the tympanum of *S. p. purpurascens* (incorrectly as *S. mexicanum).* Salfi (1935) merely comments on the gratly produced head of *Omura* (also as *Protomachus)* which causes it to have what he terms a metahypognathous,, oxycephalous form. Beier (1955, 1971) notes that the elongation of the fastigium of the head of *Omura* (as *Protomachus)* has resulted in a distal positioning of the antennal bases.

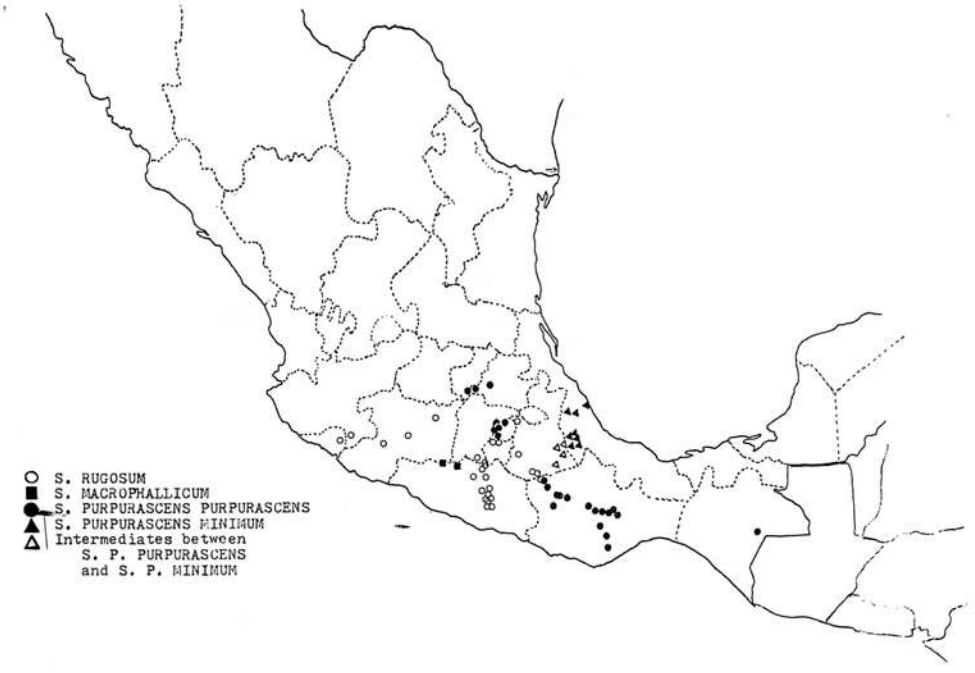

Fig. 4. Known distribution of *Sphenarium* in Mexico (2).

Kevan *et al.* (1964) and Kevan (1966), in addition to figuring the genitalic structures, illustrate various other external morphological features of Icthiacridini and Ichthyotettigini, and of Omurini. Morphological and colour variations in *Sphenarium* are discussed by Boyle (1974) and Kevan and Boyle *(in preparation).*

Very little information has been published on internal anatomy other than that directly associated with copulatory structures. Laird (1943), however, notes that the male gonads are of a radiate type in *Ichthyotettix mexicanus* and *Sphenarim (mexicanum) bistrio,* and Banerjee and Kevan (1962) comment that the brain is horizontal (rather than subvertical) on account of the anteriorly-produced form of the pyrgomorphid head in *Sphenarium p. purpurascens* (as *S. mexicanum);* they also note that the three dorsal

gastric caeca of this species are smaller than the ventral ones. In summary, knowledge of the anatomy of American Pyrgomorphidae is fragmentary, although, relatively speaking, it is scarcely more so than for Old World Pyrgomorphidae, with the exception of a few well known genera, such as *Poekilocerus, Zonocerus* and *Atractomorpha.*

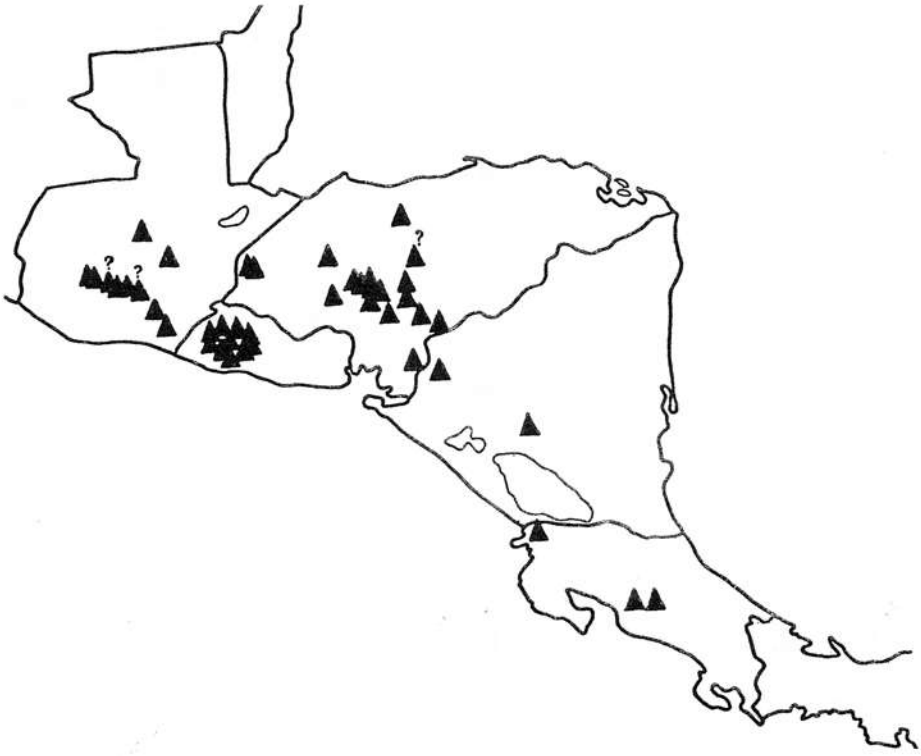

Fig. 5. Known distribution of *Prosphena scudderi* Bolívar in Central America (After Kevan *et al.,* 1964).

CYTOLOGY

Only *Sphenarium* among American Pyrgomorphidae, has been at all studied cytologically. In 1930, McClung (1932) presented a paper at Montevideo, in which he illustrated the metaphase chromosomes of (presumably) *S. m. mexicanum.* An important cytological principal was demonstrated, namely, that chrosmosome fusion may occur, and he reported a chromosome number 2n♂ = 17 in some specimens– i. e. a difference from the modal number of 19 for Pyrgomorphidae generally. In a later paper (McClung, 1941), he also gave further details of the chromosomes at prophase in spermatocyte formation. Various subsequent authors (listed by Kevan, 1977) refer to his work. Powers (1942) compared the chromosomes (number 2 n♂ =19) in *S. (m.) mexicanum* and *S. (p.) purpurascens* with those of other Acridoidea. Giral (1954) notes that the diploid chromosome number of two species in n = 10. Helwig (1958) refers to *S. (p) purpurascens* in his discussion of the importance of cytology to taxonomy.

BIOLOGY AND ECOLOGY

Remarkably little is known of the biology and ecology of American Pyrgomorphidae, despite the fact that one of them has been known for more than 200 years: Houttuyn (1766) figured what was undoubtedly a Surinam specimen of *Omura congrua* (although he seemed to think it was African), likening it to Linnaeus' *"Gryllus Acrida Nasuta"*.

Omura congrua seems to prefer areas of high humidity and it is believed that since it has a depressed body-form, it usually rests motionless, closely adpressed to the petioles or midribs of leaves, or, since it is sometimes striped, to woody stems; it has been observed most frequently on vegetation along forest trails, but it has also been taken on low trees in drier situations (Kevan, 1966). An illustration (not identifying the insect) by Zahl (1959) is accompanied by a caption stating that it was found on a blossom cluster upon which it was alleged to feed. The figure shows the insect clinging upright on an unidentifiable stem. Another (anonymous) caption to the same figure published later (Zahl, 1976) is misleading as it suggests a grass habitat. *Minorissa* seems to prefer areas of low vegetation in generally moist open environments, and *Algete* apparently feeds on some sort of (labiate?) weed (Kevan, 1966) as well as (presumably) other vegetation.

There seems to be virtually no information on the biology or ecology of Ichthiacridini or Ichthyotettigini except for an occasional indication of their general habitat, and a note by Márquez Mayaudon (1968) that he found adults of *Ichthyotettix mexicanus* in the Federal District of México from April to June.

A little more is known for *Sphenarium.* Máquez Mayaudon (1962) indicates that adults of *S. (p.) purpuracens* and *S. [m.] mexicanum* seem to appear in september and to disappear by mid January, mating from October to November. Among Plants eaten are the Compositae *Vigniera dentata* and *Helianthus annuus,* of which they consume many "pétalos" (i.e.ray florets). In the laboratory, *S.p.purpurascens* deposited egg–pods containing 15-20 eggs a few centimeters below the soil surface. Four numphal instars are reported and the development is said to be rapid. The egg stage probably lasts from January until August. The same author (Márquez Mayaudon, 1965) found adult *"S. purpurascens"* in numbers (many of them *in copulo)* from September to November, mostly on Compositae [It is possible that the species was, *S. rugosum* as I have not seen *S. p. purpurascens* from the state referred to (Guerrero), although the latter is widely distributed and may indeed have been involved]. *S. p. purpurascens)*: is also recorded in the Federal District of México from July until November (jueveniles, males and females) by Márquez Mayaudon (1968). At the International Congress of Entomology, held in Washington, 1976, this author mentioned that *S. mexicanum* has one generation per year, breeding about September. Nava Pastrana (1975) tested the colours preference of S. [*p.*] *purpurascens* and, in preliminary experiments, found that the "colours" of preferred surfaces were white and grey, and that red, green and black, were the least favoured of those tested. It is inferred that yellow, brown and blue were intermediate in attractiveness. Similar results were found for adults and nymphs.

BIOCHEMISTRY

Although there seems to have been no study on any aspect of the physiology of American Pyrgomophidae, there have been a few biochemical investigations on *Sphenarium.* Giral (1946) analysed the bodies of *S.* [*p.*] *purpurascens* for fats and mineral content, and the same author (Giral, 1954) later tested two species of the genus (presumably including *S. p. purpurascens)* for the presence of toxic sulphur compounds (such as were found in the romaleid, *Taeniopoda* and the acridids, *Melanoplus* and

Schistocerca); he obtained negative results. Grimaldo *et al.* (1958) give an analysis of the nitrogen, protein, cystine and tyrosine contents of "chapulines" *(Sphenarium* spp. - see below). Massieu *et al.* (1959) also give several analyses of the chemical composition of "chapulines", which showed a high content of protein, calcium, phosphorus, and niacin. A number of subsequent authors quote one or another of the above references; they are listed by Kevan (1977).

USE AS HUMAN FOOD

Although the word *chapulli* (derived from ancient Mexican or Aztec) seems to have originally referred to abundant (edible?) grasshoppers of several genera, including *Sphenarium,* that formed the basis of many place-names (Morales Agacino, 1956), the modern "chapulin" is applied particularly to *Sphenarium* species, which have been articles of human diet in Mexico (particularly in Oaxaca) since before the Spanish conquest, and they are still eaten today (Grimaldo *et al.* 1958; Massieu *et al.* 1959). They may be dried for future use or fried, and they appear to be of considerable nutritive value (Massieu *et al.,, op. cit.).* A number of subsequent authors have cited the references given, and these are listed by Kevan (1977). Márquez Mayaudon, also mentioned the use of *Sphenarium* as human food in an address at the International Congress of Entomology, Washington, 1976. DeFoliart (1975), who refers to Massieu *et al.* (op. cit.), suggests various additional uses for the insect protein.

CROP PESTS

The only American pyrgomorphid genera that have so far proved to be crop pests are *Sphenarium* and *Prosphena,* although there is actually a single record of *Algete* being taken on cotton (Kevan, 1966). *Sphenarium* is included among long known Mexican agricultural pests by Morales Agacino (1956). *S. p. purpurascens* is referred to, along with *Melanoplus mexicanus mexicanus,* by Bosque Flores and Delgado (1951), as causing serious damage year after year to alfalfa, barley, red peppers, vegetables, maize, oranges, soya beans, tobacco and other crops, in pratically all Mexican states (though only 12 are mentioned by name). It is not indicated which crops or states are included for *Sphenarium* (which is certainly unrecorded from some of the latter). Only some states that harbour *Sphenarium* (see Table I) are included among those from which *S. p. purpurascens* is known, so that it is difficult to judge the importance of this or other species from the information given by these authors. The difficulty of identification is, in fact, pointed out. This paper also refers largely to *Schistocerca* and gives an account of various experiments with different insecticides, such as benzene hexachloride, chlordane and parathion, but what part of the work refers specifically to *Sphenarium* is not clear. The paper indicates that much more work needs to be done on all economic aspects. Boush (1954) states more specifically that *S. p. purpurascens* adults were almost wholly involved in a number of serious "grasshopper" outbreaks, particularly in the coastal and southern regions of Mexico in the late summer of 1952, and that the species is an annual pest in the Central Mesa. It was thought that the grasshoppers imigrated into the fields, as weeds and grasses were severely defoliated at the margins of fields and along ditches. Tests using seven different chlorinated hydrocarbon and organophosphorous insecticides against the insects were carried out in the field and in the laboratory. That *S. p. purpurascens,* can be a serious pest (occurring in very large numbers) was also indicated to me by Drs. Douglas Barnes and George B. Riley, Agriculture Division of the Rockefeller Foundation, who sent me numerous specimens taken by G. M. Riess, A. Gonzales, and F.

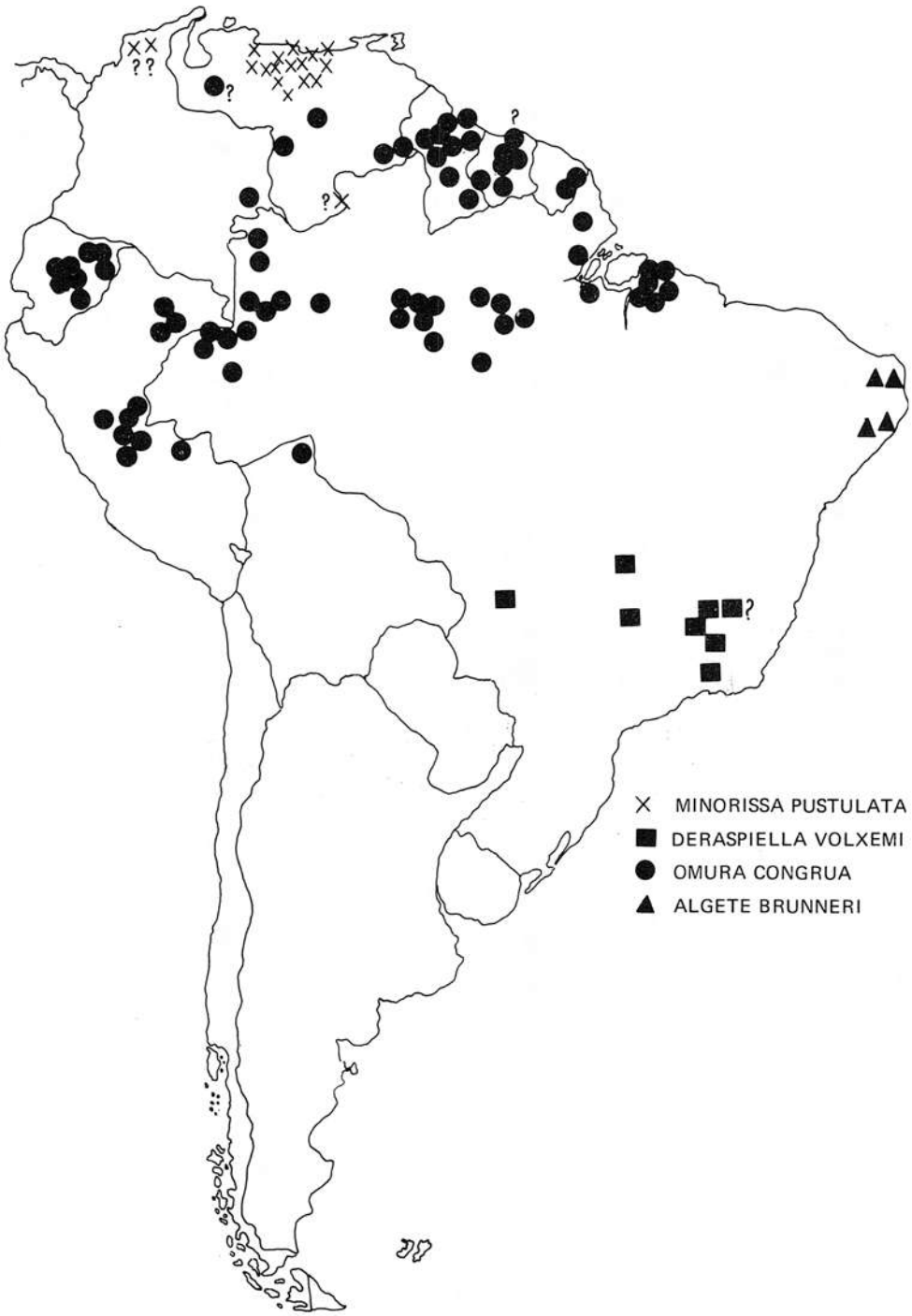

Fig. 6. Known distribution of Omurini in South America.

Gonzales dam aging crops at Chapingo, Federal District of México in September, 1954. Nava Pastrana (1975) also states that the "chapulin," *S. p. purpurascens* can be a serious pest ("plaga"). *Prosphena scudderi* also seems to be a potential, if not an actual, pest from time to time, although virtually no information seems to have been published. It is recorded from coffee in El Salvador by Berry (1953), although he notes that only a few specimens were observed.

CONCLUSION

From what has been discussed above, it may be deduced that the taxonomy and general distribution of the American Pyrgomorphidae is reasonably well understood, although several species are poorly known. The genus *Sphenarium,* in particular, however, bears further investigation from the point of view of intraspecific variation, and especially interspecific convergence or parallelism. Some valuable lessons of wider application would doubtless emerge from such studies. Certain aspects of zoogeography still need clarification, although it seems unlikely that it will be possible to deduce much further regarding relationships between American and non-American Pyrgomorphidae without the aid of fossil material.

Very little is known of the anatomy and physiology of the American Pyrgomorphidae, but the situation is not very different from that of most (but not all) Old World species of the family, and of Acridoidea generally. Earlier studies on the cytology of *Sphenarium* have proved useful, but much interesting and valuable information could be obtained from up-to-date cytogenetic studies of the genus, particularly in relation to the phenotypic variation referred to above.

Further investigations on the possible increased use of *Sphenarium,* and presumably of *Prosphena,* as human food should also be encouraged, particularly since the insects traditionally form part of the diet of local peoples. Other uses for their protein in times of particular abundance (*cf.* DeFoliart, 1975) should also be investigated.

Detailed studies on the actual and potential role, particularly of the two genera mentioned above, as crop pests are greatly needed, especially in respect of the species of *Sphenarium* that are habitually involved in different areas and as regards the ecological factors causing major outbreaks.

TABLE I - LIST OF THE KNOWN AMERICAN SPECIES OF PYRGOMORPHIDAE
Type species of genera marked with an asterisk (*)]

Tribe/Subtribe/Genus	Species/Subspecies	Primary Synonyms	Distributionn
ICHTHIACRIDINI			Mexico
Sphenacris Bolívar, 1884			E. & C. Mexico
	**S. crassicornis* Bolívar, 1884		States of Tamaulipas, San Luís Potosi, Guanajuato & Hidalgo
Calamacris Rehn, 1904			C. & W.C. Mexico
	**C. clendoni* Rehn, 1904		States of Zacatecas, Jalisco & Guanajuato
Ichthiacris Bolívar, 1905			
	I. costulata Bolívar, 1905	*I. californica* Bolivar, 1905 (syn. nov.); *Calamacris mexicana* Bruner, 1906; *C. oculata* Bruner, 1906; *C. palmeri* Bruner, 1906	Baja California Baja California
	I. elongata Kevan *et al.*, 1964		States of Sonora y Sinaloa
	**I. rehni* Bolívar, 1905		Baja California
Atyphacris Kevan *et al.*, 1964			
	**A. californica* (Bruner, 1906)	*Calamacris c.* Bruner, 1906; *Ic* [*b*] *thiacris aptera* Hebard, 1932	Baja California

ICHYOTETTIGINI			**Mexico**
Sphenotettix Kevan *et al.*, 1964			**E.C. Mexico**
	**S.nobilis* Kevan *et al.*, 1964		State of Hidalgo
Pyrgotettix Kevan *et al.*, 1964	**P.pueblensiss* Kevan *et al.*, 1964		States of Puebla & (?) Oaxaca
	Pyrgotettix n. sp.? [Kevan*et al., 1971*]	*P. pueblensis* Kevan *et al.*, 1964 *(partim)*	State of Oaxaca
Piscacris Kevan *et al.*, 1964			**S. Mexico**
	P. affinis Kevan *et al.*, 1964		State of Oaxaca
	**P. robertsi* Kevan *et al.*, 1964		State of Guerrero
Ichthyotettix Rehn, 1901		*Ichthydion* Saussure, 1859 *(nec* De Jean, 1833)	**C. & S. Mexico**
	**I. mexicanus* (Saussure, 1859)	*Ichthydion mexicanum* Saussure, 1859	States of Jalisco (E.) Michoacán (E.), Hidalgo México (+ Dist. Fed.), Morelos, Guerrero, Puebla, Vera Cruz (W.), Oaxaca & Chiapas

SPHENARIINI			**Mexico, Central America S.W. China - S.E. Tibet N.E. India, Madagascar, Sokotra L., E. Africa.**
SPHENARIINA			**Mexico, Central America**
Prosphena Bolívar, 1884			**Central America**
	**P. scudderi* Bolívar, 1884		Guatemala, El Salvador, Honduras, Nicaragua & Costa Rica
Sphenarium Charpentier, 1842			**Mexico & Guatemala**
	S. borrei Bolívar, 1884		D.W. Mexico: States of Nayarit, Jalisco, Colima &Michoacán
	S. mexicanum histrio Gerstaecker, 1873	*S.bistrio* Gerstaecker, 1873; *S.carinatum* Bolívar, 1904; *S.magnum* Márquez Mayaudon, 1962 [intermed. to *S. m.mexicanum*]	S. Mexico: States of Michoacán, Guerrero, Oaxaca & Chiapas; S.W. Guatemala
	S.m.mexicanum Saussure, 1859	*S. mexicanum* Saussure, 1859; *Opomala ? crassipes* Walker, 1870; *S. ictericum* Gerstaecker, 1873; *S.bolivari* Bruner, 1906 [intermed. to. *S.m.histrio*]; *S. marginatum* Bruner, 1906	E. Mexico: States of Vera Cruz & Tabasco [intermediates to *S.m. histrio* in N. Oaxaca]
	S.purpurascens minimum Bruner, 1906	*S.minimum* Bruner, 1906; *S.affine* Bruner, 1906	E.C. Mexico: State of Vera Cruz (C.)

	**S.p.purpurascens* Charpentier, 1842	*S.purpurascens* Charpentier, 1842; *S. planum* Bruner, 1906 [intermed. to *S.p. ninim um*]; *S.bruneri* Solivar, 1909	C. & S. Mexico: States of Queretaro, Hidalgo [incl. intermediates to *S.p.minimum*], Mexico (+ Dist. Fed.), Morelos (N.) Puebla[incl. intermediates to *S.p. minimum*], Vera Cruz (W.C.) [intermediates],, Oaxaca & Chiapas
	S.rugosum Bruner, 1906	*S.barretti* Bruner, 1906 (syn.nov.)	W.C. Mexico: States of Jalisco (S.), Colima, Michoacán, México (+ Dist. Fed.), Morelos, Guerrero,, Puebla (S. & W.) & Oaxaca
	S.cariabile, n. sp.	*Sphenarium,* n.sp. a [Kevan *et al.,* 1974]	S. Mexico: State of Oaxaca
	S.macrophallicum, n. sp.	*Sphenarium,* n.sp. *b* [Kevan *et al.,* 1974]	W.C. Mexico: N.W. State of Guerrero
OMURINI			**Tropical South America**
Minorissa Walker, 1870		*Phymaptera* Bolívar, 1884; *Mestraoides* Willemse, 1933	**N.W. South America**

	**M.pustulata* Walker, 1870	*Phymaptera jucunda* Bolívar, 1884; *Mestraoides javana* Willemse, 1933	Venezuela: Distrito Federal (Carácas); Provinces of Miranda, Aragua & ? Amazonas; Colombia: ? N. (needs confirming))
Deraspiella Bolívar, 1905		*Deraspis* Bolívar, 1884 (*nec* Blanchard, 1845)	**Brazil**
	**D.volxemi* (Bolívar, 1884)	*Deraspis* v. Bolívar, 1884	C. & E. Brazil: States of Goiás and Minas Geraes[2]
Omura Walker, 1870		*Protomachus* Stal, 1876	**N. & C. South America**
	**O. congrua* Walker, 1870	"*Gryllus* Acrida *Nasutus*" Houttuyn, 1766 (*nec* Linnaeus, 1758); *Protomachus depressus* Stal; *O.congrua* var. *brunneri* Bruner, 1911	Amazon & Orinoco drainage basins to headwater systems from the Guianas west almost to the Andes; Guyane[3] ; Surinam; Guayana; Venezuela: Provinces of Bolívar, Amazonas & ? Tachira; Colombia (E.):

		Province of Vaupés; Brazil: States of Amapá, Pará, Amazonas (E. to W.) & ? N. Matto Grosso; Ecuador (E.)[4] ; Péru (E.): Provinces of Loreto & Huánuco; Bolivia (N.E.): Province of Beni
Algete Bolívar, 1905		**N.E. Brazil**
	**A.brunneri* Bolívar, 1905	N.E. Brazil: States of Rio Grande do Norte, Paraiba (?) & Pernambuco

1 There are also two specimens allegedly from the States of Sinaloa and Sonora but these are doubtless mislabelled. There are also undoubted specimens from an isolated locality in coastal Vera Cruz (Cerro Gordo) which do not fit well in the distributional picture as it is presently known. 2 *D. volxemi* was previously known (Kevan, 1966) only by 2 females: the holotype (no data closer than "Brasil") and a specimen from Anápolis. Another female has now come to light ("Goiás: Goiatuba [18° 01'S, 49° 18'W.]. Nov. 1961, W. Bokerman), together with a last-instar female nymph from further to the south-east ("*Minas Geraes:* Varghina, 45° 52'W., 22° 20'S., Sept. 1961, Seabra & Alvarenga). Both specimens are in the collection of the Museum of Zoology, University of Michigan, Ann Arbor, Michigan. The nymph is clearly identifiable by the peculiar and characteristic, long, pointed lateral pronotal lobes, but it is of rather different appearance from the adult. 3 A further record from Guyane in addition to the two recorded by Kevan (1966) is given by Descamps and Amedegnato (1970) for Carnope, Oyapock [= R. Oiapoque]. 4 Further records for eastern Ecuador, in addition to those given by Kevan (1966), are for *Napo-Pastaza:* 1 male, 2-8 miles N. of Puyo, 953 m., 9.II.1955; 2 males and 2 females, 6-8 miles W. of Mera, 1500 m., 10.II.1955; all Schlinger & Ross (California Academy of Sciences, San Francisco).

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APPENDIX I

NOTES ON ICHTHIACRIDINI

Since the revision published by Kevan *et al.* (1964), a number of additional specimens of Ichthiacridini, particularly of the genus *Ichthiacris* from Baja California Sur, have come to my attention, and, in view of how poorly known this group is, it is of interest to publish the additional locality records and to comment briefly upon other matters relating to the various species. For the opportunity of examining most of the material, I am grateful to Dr. Eric Fisher, Department of Biology, California State University, Long Beach, California, to whom acknowledgement is also due for assistance in locating some of the more obscure localities that do not appear on standard maps such as that of the National Geographical Magazine, Vol. 103(3), "Mexico and Central America", published in 1953, or that of the Automobile Club of Southern California and the California State Automobile Association, Map No. 2011, "Baja California", issued August, 1970.

Ichthiacris rehni Bolivar, 1905

I. rehni has previously been recorded from Baja California Sur from the following localities (Kevan *et al.* 1964): 20 miles S. of El Arco [which is itself in Baja California Norte], Arroyo Seco [about 25 miles due W of La Paz; there is another in Baja California Norte near Colonet, inland from San Antonio del Mar, but it is not likely to be this one], Coronados I., Danzante I., 12 miles N. of La Paz on road to Pichilingue, Loreto, San Marcos I., Triunfo, 13 miles NW of El Triunfo. In addition, Kevan *et al. (op. cit.)* record six immature specimens from "[Sierra de?] San Lázaro" [presumably = Sierra de la Victoria, the more recent name for these mountains, and not Cabo San Lazaro on the west coast, as the collector, Eisen, does not appear to have visited the latter, although he collected material in the extreme south over at least three seasons, 1893, 1894, and 1898, that in question being 1894]. On a re-examination in the presence of more material including juveniles of *I. rehni* and *I. costulata,* at least one, and possibly all of these, immature specimens have been found to belong to the latter species. Kevan *et al.*, also record the species from [Rancho] Mesquital in Baja California Norte, about 30 miles NW of El Arco.

The following additional material of *I. rehni* from Baja California Sur, received from Dr. Fisher, has also been examined (all collected by E. L. Sleeper and F. J. Moore, unless otherwise indicated): La Paz, 50 ft., 6.X.1968, 3 ♀♀; 59 miles NW of La Paz, 600 ft., 17-18.XI.1968, 1 ♂; NW of La Paz, 600 ft., 24-28.XI.1968 (E. L. Sleeper only), 1 ♂; 3 miles SE. of Pozo Grande, 400 ft., 15-16.XI.1968, 1 ♂, 1 ♀; 19 miles SW of San Miguel Comondu [just W. of San José C.], 800 ft., 14-18.XI.1968, 1 ♂, 2 ♀♀; San Rita [just N. of La Salada], 400 ft., 16-17.XI.1968, 1 ♂, 1 ♀; 2 miles SE. of Santa Rita, 420 ft., 16-17.XI.1968 (collected at "Blacklite"), 1 ♂; Valle Perdido [a few miles S of San Antonio], 1800 ft., 27-29.XI.1968 (E. L. Sleeper), 1 juv. (♀).

Apart from the narrower, more acute fastigium of the vertex and more oblique frontal profile noted by Kevan *et al.* (1964), *I. rehni* differs from *I. costulata* in that the metathoraic epimeron is narrower and less "flared" (*cf.* figures in Kevan *et al.*), and that the integument is more strongly longitudinally ridged. There is, however, a considerable variation in the degree of rugosity. Most commonly the thorax in particular bears numerous small, but quite prominent, almost prickly, tubercles along the ridges. Kevan *et al.* (*op. cit.*, caption to Plate I) suggest that the less strongly tuberculate condition is more normal, but the reverse would now seem to be the case. *I. rehni* also differs from *I.*

costulata in usually having slightly larger particularly wider tegminal vestiges, although these vary (Kevan *et al.* illustrate an extra-narrow form, more common in males). The posterior (dorsal) margin is always quite straight, but the anterior margin is usually very strongly and abruptly curved toward the apex (not as illustrated by Kevan *et al.*, which is a less usual condition, rarely found in females, even when the tegminal vestiges are very short).

Ichthiacris costulata Bolívar, 1905 (=*I. californica* Bolívar, 1905 - *syn. nov.)*

Ichthiacris costulata is recorded by Kevan *et al.* (1964) from the following localities in Baja California Sur: Cabo San Lucas, Corral de Piedra (Sierra de la Taste [about 15 miles W. of Santa Anita]), 12 miles N. of La Paz on road to Pichilingue, Patrocinio [about 32 miles S. of San Ignacio], San José del Cabo. To these should be added San Lazaro on the basis of the immature specimens referred to under *I. rehni.* The alleged type locality of the synonymous *Calamacris oculata* Bruner, 1906, sould presumably have read "extreme southern California", not ". . . Arizona".

Additional material more recently examined (all collected by E. L. Sleeper and F. J. Moore unless otherwise indicated) is a follows: 14 miles S. of El Arco [itself in Baja California Norte; 16-VI.1967 (E. L. Sleeper & E. M. Fisher), 1 ♂; 15 km. E. of Colonv [F. de la] Toba [now Villa Insurgente; 15 ml. NW of Villa Constitucion and almost 30 miles N. of El Refugio], 400 ft., 23-24.XI.1968 (E.L. Sleeper only), 1 ♂; 3 miles E. of La Burrera [a few miles inland from Todos Santos], 1800 ft., 17-19.X.1968, 2 ♀♀; 2.5 miles SE of La Huerta [about halfway between La Paz and Punta de la Ventana], 2200 ft., 8-9.X.1968, 2 juvs. (♂, ♀); 23.0 km. SW La Paz, 120 m. (24110 Cd), Cape thorn forest 2.VI.1973 (E.L. Sleeper only), 1 ♀; 3.5 miles W. of Los Barriles [Buena Vista] 500 ft., 2-3.XI.1968 (E.L. Sleeper only), 2 ♀♀; Santa Rita [just N. of La Salada], 400 ft., 16-17.XI.1968, 1 ♀; 0.5 miles NW of El Triunfo, 1800 ft., 10.X.1968, 2 ♂♂, 1 ♀; 7.5 miles W. of El Triunfo, 1500 ft., 2-3.XI.1968, 1 ♀; Valle Perdido [a few miles from San Antonio], 1800 ft., 27-29.XI.1968 (E.L. Sleeper only), 1 ♀; 2.7 miles SE of Valle Perdido, 1800 ft., 15-16.X.1968, 3 ♂♂, 4 ♀♀.

Many of the specimens listed above have the hind femora reddish in colour (particularly on the inner faces) to varying degrees, namely, those from El Arco, Colonia Toba, La Burrera, Los Barriles (one only), Santa Rita, W. of El Triunfo, and SE of Valle Perdido (males only). This is probably the normal coloration for sexually mature individuals. The Los Barriles and La Burrera females, and more especially one of the latter (which is also rather more robust than normal), have the fastigium of the vertex distinctly broader, and thus proportionately shorter, giving the frontal profile a less strongly oblique aspect, than in the majority of specimens. The last mentioned specimen is very similar in both respects to one previously recorded and figured by Kevan *et al.* (1964) from near Pichilingue, in which, however, the hind femora are not reddened. There is thus now available a series of females intermediate in external morphology between *I. costulata* and *I. californica.* The female paralectotype of the latter seems to differ from *costulata* specimens with a broad fastigium only in that the vertex appears to be rather more convex in lateral view. Males also are variable, but, having generally narrower fastigia of the vertex than females, any differences between them in this character are less clear. I have, however, seen no other male with a fastigium as wide as in the lectotype of *I. californica.* The phallic structures of all males examined, including the lectotype, are quite similar, however, and there seems to be no satisfactory reason for recognizing the two nominal species as distinct from each other, particularly as they are sympatric. It may be noted that the name *I. californica* has page priority over *I. costulata* and that it was described from both sexes (*I. costulata* was based on an unique female type), so that *I. californica* would be the logical selection for a name. In view of the confusion which arose over the specific name of the related *Atyphacris californica* (Bruner), however, it would seem preferable to select *costulata* as the name for such a combined taxon. The selection of the name having page priority is not mandatory according to the International Code of Zoological Nomenclature.

It is interesting to note that, in the original descriptions, very little is given to distinguish *I. costulata* from *I. californica.* In the latter, the tegminal vestiges are said to be very narrow and black-bordered; in the former, they are said to be very small, passing the posterior margin of the mesonotum, their "interior" (posterior) margins straight and their "exterior" (anterior) margins curved; no contrasting character for the two "species" is thus given. In fact the tegminal scales of female *I. costulata* vary considerably, from being extremely minute, parallel-side, apically rounded and not much more than twice as long as wide, to being clearly visible, with the anterior, and sometimes both margins slightly convex and three times as long as wide (*cf.* figure in Kevan *et al.*, 1964); the anterior margin may be black and the rest of the tegmen-scale red, or the whole may be more or less concolorous with the body. The male tegminal vestiges are usually very small and narrow and often more or less sealed with the thorax. The only other supposed differences given in the original descriptions are in the hind legs. The hind femora of the *I. californica* are said to be red internally and the genicular lobe to have a dark mark surrounded paler; *I. costulata* is not noted as having these features, but the hind tibiae are said to be pale; in *I. californica* the hind tibiae are said to have griseous hairs and to be fuscous above the pale in the middle. The *I. costulata* material examined may or may not have any of the characters given for both. It may be noted that the last instar nymphs of this species are very like adults, as external genitalia are quite developed in the males, but the phallic structures are undeveloped, and the tegminal scales and antennae are nymphal in character.

Ichthiacris eloganta Kevan, Singh & Akbar, 1964

I. elongata was previously known only by the type series (Kevan *et al.*, 1964), from the states of Sinaloa (26 miles N. of Pericos) and Sonora (Alamos). Two further specimens are now known from Sinaloa (California Academy of Sciences): 30 miles N of Calican on Mexican Highway 15, 28.VIII.1963 (Grant & Howard), 1 ♀; 5 miles 22.VIII.1964 (Rentz, Rentz & Grant).

Atyphacris californica (Bruner, 1906)

This species has been recorded from specific localities in Baja California Sur only from José del Cabo and "San Lazaro" (for comments on this locality, see under *Ichthiacris rehni*). The latter refers only to immature specimens, but they have been re–examined and seem to be correctly identified. In addition to these records, Kevan *et al.* (1964) report a single female having only the data "San Pedro Martir, L.C., Mex." They suggest that the Sierra San Pedro Martir in Baja California Norte is too far north to be the place in question, but the ruined mission of San Pedro Martir is quite well known and might well have been visited by the anonymous (touring) collector. As we know very little of the northerly distribution of Ichthiacridine, we cannot rule out this, in favour of another San Pedro further south, as being the locality involved. The only further record known to me is a single female labelled "Mex. Baja Calif. Sur, 3 mi E. La Burrera, E., 1800', X–17/19–1968, E.L. Sleeper & F.J. Moore". This locality is a few miles inland from Todos Santos.

Sphenacris crassicornis Bolivar, 1884

The only other unpublished record of an ichthiacridine that is currently at hand is of a male and a female of *Sphenacris crassicornis* from the state of a male and a female of Sphenacris crassicornis from the state of San Luis Potosi, El Salto, 1000 ft., 3.XI.1962 ([H.R.] Roberts).

In the Ichthyotettigini, an additional record of a male of *Ichthyotettix mexicanus* (Saussure, 1859) may be noted: Hidalgo State, 7.5 miles SE of Ixmiquilpán, 6,700 ft., 1.IX.1962 (Ordway & Roberts).

APPENDIX II

PRELIMINARY DIAGNOSES OF TWO NEW SPECIES OF *SPHENARIUM CHARPENTIER*

D. K. McE. KEVAN AND W. K. BOYLE

(Further descriptions to be published later)

Sphenarium variabile n. sp.
(Fig. 7)

As in all species of *Sphenarium,* variable in size, body form, and coloration; generally very similar in appearance to various forms of *S. purpurascens purpurascens* Charpentier, having its very short robust shape, but easily distinguishable in the male sex from all other species of the genus by the comparatively short endophallus with short gonopore processes (aedeagal sclerites) and aedeagal valves (Fig. 1,B,C). *Holotype:* ♂; "Mexico, Oaxaca, 18 mi. NW La Reforma (km. 695 on Hwy. 190; 32 mi. WNW Tequisistlán), 2750', 14 Sept. 1959 (I.J. Cantrall – T.J. Cohn, Nº 116)" [Museum of Zoology, University of Michigan, Ann Arbor, Michigan]. *Allotype:* ♀; same data as holotype. *Measurements:* body length, ♂20, ♀19.5; pronotum, ♂5.0, ♀6.5; hind femur; ♂12.6 x 3.1, ♀13.0 x 2.9; tegmen, ♂4.3, ♀5.2 mm. *Paratypes:* 51 ♂♂, 17 ♀♀, from various localities in the State of Oaxaca: same data as holotype; 2 & 13 mi. SE Talcolula; 45 mi. NW Tequisistlán; Mitla, 5000 ft.

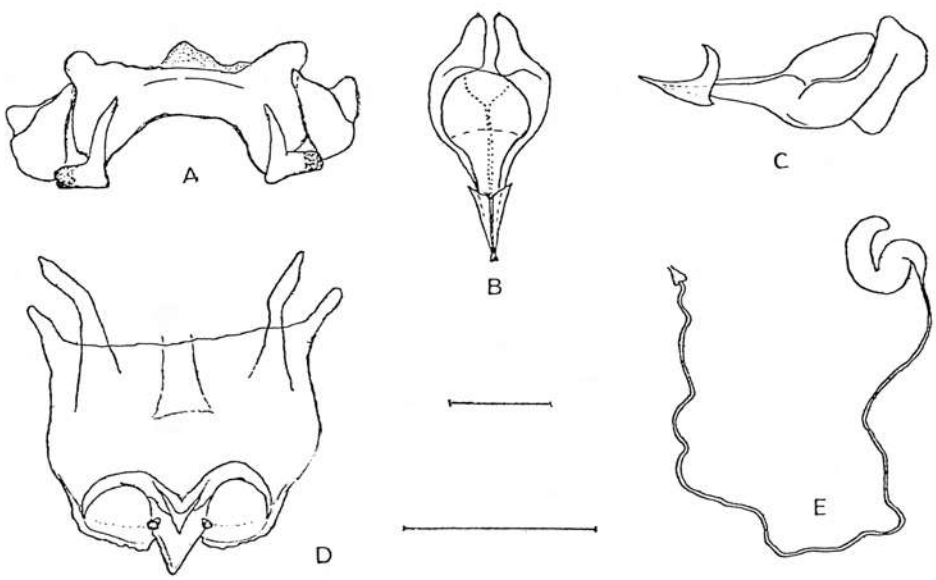

Fig. 7. *Sphenarium variabile,* n. sp., Kevan & Boyle; concealed copulatory structures. A-C,♂; D,E,♀.

Sphenarium macrophallicum n. sp.
(Fig. 8)

Apparently not quite so variable in size, body form and coloration as some species of *Sphenarium;* generally rather similar to *S. mexicanum* Saussure and S. *rugosum* Bruner, having a rather more fusiform appearance than *S. purpurascens* or the above species; easily distinguishable in the male sex from all other species of the genus by the elongate endophallus with extremely long, upwardly curved gonopore processes (aedeagal sclerites) and aedeagal valves (Fig. 2,B,C). These are even longer than in *S. purpurascens* (cf. Kevan, Akbar & Chang, 1974). *Holotype:*♂; "Mexico, Guerrero, 11 road mi. NE of Arcelia, 3000 ft. 8 Dec. 1958 (T.J. Cohn, No. 360)" [Museum of Zoology, University of Michigan, Ann Arbor, Michigan]. *Allotype:*♀ ; "Mexico, Michoacan, Ciudad Altamirano, 20 Oct. 1957 (P. Douglas)" [Museum of Zoology, University of Michigan]. *Measurements:* body length, ♂ 24.6, ♀ 26.5; pronotum, ♂ 5.6, ♀ 8.9; hind femur, ♂ 12.8 x 3.2, ♀ 17.6 x 3.4; tegmen, ♂ 5.4, ♀ 6.3 mm. *Paratypes:* 2♂♂, same data as holotype; 1 ♂, 1 ♀, Guerrero, Temisco, X-XI, 1928, Dr. T.W. Bouchelle; 1 ♂, 1 ♀, same data as allotype.

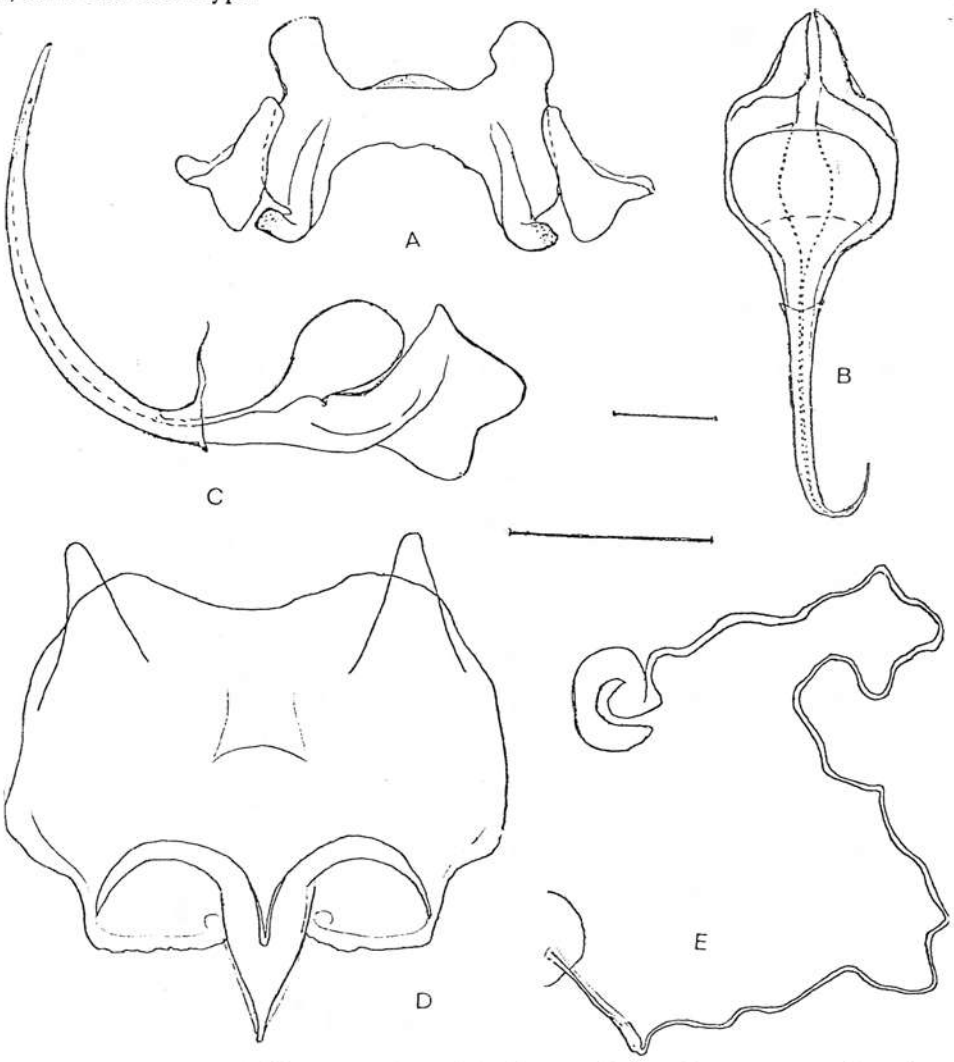

Fig. 8. ***Sphenarium macrophallicum*** **n. sp., Kevan & Boyle; concealed copulatory structures. Lettering and scales as in Fig. 7.**

ADDENDUM

D. K. McE. KEVAN

POSTSCRIPT

Subsequent to the writing of the above, I have read an important contribution by M. Descamps, 1975: "Etude du Peuplement acridien de l'Etat du Veracruz (Mexique)", *Fol. ent. mex. 31-32:* 3-98, which mentions several species from the state mentioned in its title. It gives useful ecological notes on *Sphenarium mexicanum* and *S. purpurascens minimum.*

It should perhape also be noted that there is mention in the same paper of a species called *Halffterina albosignata,* and that this was listed as a new genus and species of Pyrgomorphidae in *Entomological Abstracts, 8* (2): 12 (1977). It was implied that it was a *nomen nudum.* It is, in fact, a member of the acridid subfamily Ommatolampinae, and not a pyrgomorphid. The error is understandable in an abstracting journal because, through some oversight, the family name Acrididae has been omitted from the appropriate parts of the original text.

The actual description of the genus and species (in the appropriate Family) vas given, together with the description of a second Mexican species of the genus *H. furculata* (which was not taken in Veracruz), by M. Descamps, May-June, 1975: "Le groupe des Eucopiocerae (Orth. Acrididae Ommatolampinae)", *Bull. Soc. ent. Fr. 80:* 119-131.

In conclusion, it might also be mentioned that a third adult female specimen of *Deraspiella volwemi* has been discovered in Brazil by M. Descamps, in State of Matto Grosso, Rte. 163, Corrego Boa Vista, 22-I-1972 (Paris Museum). It has very slightly longer tegmina that only other known complete adult, their apices very nearly reach the wind knees.

The actual type locality of *D. volxemi* is uncertain, but it seems that Camille Van Volxem, on his visit to Brazil in 1872, proceeded in the direction of Belo Horizonte, Minas Gerais, and it is most probable that his specimen came from the Atlantic forest zone NNW of Rio de Janeiro, no further north than this locality (Dr. M. A. Monné, Museu Nacional, Rio de Janeiro, personal communication, 1978). Be that as it may, a fairly extensive collection of the species, including males, has very recently been made from three localities in the state of Minas Gerais during November, 1977, by Seabra, Monné and Roppa, as follows: Contagem [W. of Belo Horizonte], 9 ♂♂, 5 ♀♀; Barroso, 4 ♂♂; Tiradentes, 4 ♂♂, 4 ♀♀ (in collection of Dr. C.A.C. Seabra, Rio de Janeiro; 1 ♂, 1 ♀ from Contarem donated to the author and a further pair to Acadamy of Natural Sciences of Philadelphia). A full account of this material, with a description of the male is to be published later by Drs. Seabra and Monné. Males are considerably smaller than females, much more strongly brachypterous, the posterior part of the pronotal disc is not extravagantly produced as it is in the females, and the curious triangular posterior projections of the lateral pronotal lobes are less exaggerated.

Dr. Seabra's collection also provides further Brazilian records of *Omura congrua,* as follows:

Pará: Belém, 15.V.1952, O. Rego col., 2 ♂♂; Mocambo, Belém, 30.XI.1977, J. Becker col. 1 ♂, 1 ♀ juv.; Obidos, XII.1955, F.M. Oliviera col., 2 ♂♂, 3 ♀♀; V.1961, José Brazilino col., 1 ♂, 1 ♀.

Amazonas: Atalaia do Norte, XI. 1977 B. Silva col., 1 ♂; Benjamin Constant, VII. 1977, B. Silva col., 1 ♂, 1 ♀; Manacapurú, X.1977, Descamps, Naville & Becker col., 1 ♂; Tabatinga, X.1977, B. Silva col., 1 ♂, 3 ♀♀.

It may also be noted that the dubious record of this species for the State of Matto Grosso given by Kevan (1966) is incorrect. The Benevides locality in question is in Pará state, S.W. of Belém.

MUCH NEEDED REVISIONARY STUDIES OF NEOTROPICAL GRASSHOPPERS AS SEEN FROM CURRENT WORK ON THE SUBFAMILY LEPTYSMINAE

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Several, years ago I attempted to prepare a faunistic report, with a sizable collection of grasshoppers available from the vicinity of Puerto Lopez in the llanos of Colombia. There was no problem distinguishing the species present, but to apply a valid name to them appeared to be a hopeless task. Recently there have been a few excellent revisionary studies on groups of Neotropical grasshoppers, but the great majority of them have not been critically studied, and it is my impression that many of the groups remain in a state of confusion. This is largely due to the lack of published information on the identification of the older types in Europe and the indiscriminant description of species by Lawrence Bruner in the early 1900's.

I subsequently began a revisionary study of the tribe Leptysmini both because the need seemed great and because the tribe appeared to have many useful and interesting morphological characters. Based on this research I will attempt to outline some recommendations on what appear to be the most pressing needs of Neotropical grasshopper systematics for the inmediate future.

The tribe Leptysmini includes some forty species and subspecies, and it is most commonly represented by the genera *Leptysma* and *Stenacris*. This tribe is closely related to and probably derived from the other major tribe of the subfamily, the Tetrataeniini, which is commonly represented by the genera *Cornops* and *Inusia*. The subfamily Leptysminae is peculiar to the American tropics except for a few species that reach the north temperate zone and a few that reach central Argentina.

To begin this study several thousand specimens were assembled through loans from other museums, especially the Museum of Zoology of the University of Michigan, together with the large collection of the Academy of Natural Sciences of Philadelphia. This assemblage of specimens included examples from virtually all of the geographical areas from where the tribe has been reported. However, there are still extensive areas in the Amazon Basin and elsewhere which remain to be explored. After a preliminary survey of the tribe, I undertook a revision of the genus *Cylindrotettix*, wich included 13 species and subspecies. This study was completed in early 1975 and published later that year. This has been followed by a study of all of the remaining genera and species of the tribe, and it would have been completed by now were it not for an unfortunate motor accident that befell me.

The most challenging part of a systematic study of a large collection is the search for the distinguishing characters of a species or how it may be most easily distinguished from all similar species. The next step is to determine whether the distinguishing or diagnostic characters become modified in populations from one geographical area to another. This latter frequently involves considerable judgment and experience. If one

examines the literature one will often find a wide-ranging species has been described and named many times from a number of major geographical areas. It seems that many past authors have simply assumed that a species from one geographical area, let us say, Venezuela could not possibly be the same species as a similar-looking one from eastern Bolivia.

As an example of this sort of work, Bruner (1906) described and named a species from Sao Paulo, Brazil. The description is only a brief key with mention of the locality. Later that same year he described as new a species from Trinidad based on two females. He does say that this species is nearest to his species from Sao Paulo but gives no indication as to how they might differ. I sense that he really believed that his two species must be different and that it was simply a matter of someone else comparing the two species to find the differences. Incidently, both of Bruner's names prove to be junior synonyms of Serville's *Leptysma filiformis,* also described from Sao Paulo.

Another example of describing a species several times from different geographical localities is furnished by Rehn and Eades (1961) description of a "new species" from Vera Cruz, Mexico, and a new genus *Belosacris,* that included it along with two of Bruner's species from Paraguay and French Guiana. Although some 550 words describe the new genus and species, the only comparisons made with existing species is to state that, for the male type, "size somewhat smaller", and, for the allotype, "cerci are smaller", as compared to Bruner's species from Paraguay. As you might suspect, I can find nothing of any significance to distinguish the populations of this wide-ranging species. The Rehn and Eades proposal of a new species exemplifies two common faults of the past. The first fault lies in the assumption that species found distant from the known range of a species must belong to a different species. Bruner made the same error as Rehn and Eades in this regard when he described his species from French Guiana in 1911, and comparing it with his 1906 Paraguayan species he gave only slight size and color differences wich are of no significance. The second and more serious fault lies in the lack of information given on the characters that distinguish a species from other species of the genus. For some reason past authors seem to have believed that a careful, objective description of the type justifies and validates the proposal of the new species, and apparently assumes that students in the future can read such descriptions and recognize the species from all others. In my experience such descriptions are rarely of any use. For example, Rehn and Eades' description of the hind femur of their new species runs to 30 words though I suspect the description could apply equally well to every species in the tribe.

This comparison of populations from relatively distant geographical areas is complicated when minor differences such as color patterns become evident. I refer specifically to *Stenacris xanthochlora* (Marschall), generally known in the past as *S. cylindrodes* (Stal). This species ranges from Vera Cruz, Mexico, to northern Argentina. The male reproductive structures and other morphological characters that usually distinguish species of the genus are consistantly similar throughout the range of the species. On the other hand the presence or absence of a longitudinal, white body stripe, exhibits some geographical variation. Throughout most of the range of the species the white stripe is present in males and generally absent in females. One or two females in a large series of specimens from a locality will occasionally show the white stripe. From Surinam, French Guiana, and the eastern portion of northern Brazil all specimens of both sexes have the white stripe strongly developed. In Mexico and Central America the male has the white stripe, and it is usually lacking in the female though a series of eight males and eight females from Guanacaste, Costa Rica, lack the stripe in both sexes.

The presence or absence of the stripe does not appear to be related to any particular ecological or habitat condition, and I suspect that it is a genetically determined color morph. I have been unable to find any other character that can be correlated with the presence or absence of the stripe. It would seem to be more practical and useful to recognize the population as one wide-ranging species while giving recognition to this variation. Incidently, there have been seven junior synonyms proposed for this species, and Lawrence Bruner, not to be left out, proposed two of them.

In comparing populations of a species from different or distant geographical areas, I have referred to the situation in which no differentiation is evident, as with *Leptysma filiformis* and a species of *Belosacris,* treated by authors as two or more different species each. I have also just described the situation found in *Stenacris xanthochlora* in which there is some geographical variation in color pattern but not enough to warrant any formal recognition by name.

I will now discuss the situation where some significant geographic variation is evident.

In the genus *Cylindrotettix* I have found three species each with geographical differentiation in the male reproductive structures. The females cannot be distinguished. For example, I have specimens of *C. dubius* from 19 localities in southern Brazil, Paraguay, and Missiones in Argentina, all of wich have very similar reproductive structures. From four localities in eastern Peru and the Department of Santa Cruz in Bolivia I have a total of eight males, all of wich show a distinct modification of the aedeagus and also a slightly longer fastigium. In other respects there is little if anything to distinguish the populations from the two areas. The two other species mentioned show similar geographical differentiation. I have used the subspecific category to indicate their close similarity or relationship. They are allopatric in distribution, and to some degree they are probably reproductively isolated.

At a higher level of geographic differentiation I am also using the subspecific category to indicate the close relationship of four previously described species of *Stenacris.* These species have certain characteristics in common such as the shape of the ventral, relatively robust ovipositor valves and an unusually elaborate male subgenital plate. Conceivably they could even be considered a separate genus. The species are distinguished from each other by major differences in the male reproductive structures. They are all allopatric so far as known, and we can suspect that there is at least some degree of reproductive isolation. Retaining the four taxa within the genus *Stenacris* indicates that they are most nearly related to other members of the genus, and by treating them as subspecies of one species indicates their close relationship to each other as compared with other members of the genus, and suggests an allopatric distribution.

The recent scholarly study of the genus *Barytettix* by Cohn and Cantrall (1974) includes an example of the excellent use of the subspecific category. Looking at other groups of insects one can find surprising steps or stages in the process of speciation. I will refer briefly to the intensive studies on the *willistoni* group of *Drosophila* which occurs in the American tropics. A recent paper by Ayala et al. (1975) briefly describes the situation and gives references to many other papers on the subject. In the *willistoni* group of 15 species, 6 are sibling species (that is, nearly indistinguishable morphologically). All are reproductively isolated, and all are sympatric with each other in at least part of their range. Two of the sibling species have two subspecies each that are allopatric and only partly isolated reproductively in the laboratory (that is, F1 males are sterile). One of the other sibling species has 6 semispecies. A semispecies, so called, is similar to a subspecies in its degree of differentiation, but two or three of them may be sympatric with each

other at many localities. Though they hybridize in the laboratory thay apparently do not do so in the wild. I do not believe that a similar situation is likely to be found in grasshoppers, but it does remind us that the process of speciation can be complex. The intensive studies of this group of *Drosophila* was undertaken not to improve the classification of the group, but rather to investigate the process of speciation. I do believe that, with intensive studies of some of our wide-ranging species of grasshoppers, subtle differences may be found between different geographical populations, but such refinements are hardly needed at the present time.

Another difficult problem I encountered in treating the Leptysmini was the identification of types in order to find the valid name for a species. We are today fortunate in that most museum will readily loan holotypes to qualified workers. We can also be grateful to our collague, Dr. Carlos Carbonell, who traveled to Europe some few years ago and examined most of the 19th century acridid types. In many cases he found syntypes and selected a lectotype. He both photographed the types and made descriptive notes on them. He most generously provided me with needed information and photographs. With such help it was often unnecessary to examine the type.

Unfortunately, some types cannot be identified with certainty because the sex of the type does not have any known diagnostic characters. A case in point is the type of *Cylindrotettix obscurus* (Thunberg) 1827 labelled 'obscurus Amer. Merid' The type is a female, and it could very possibly be at least one other species. However, the name has long been applied to a common species, and it seems unlikely that there could be any good reason to question the identification, arbitary as it may be.

Another cause of trouble in nomenclature is the result of a pernicious disease that I call *nomenitis* (that is, a compulsion to name anything that might possibly represent a different species and let others worry about its validity). Lawrence Bruner, who proposed many new leptysmine names, was afflicted with this compulsion. Six or seven of his Leptysmini names were based on unique specimens, one of which is an injured and deformed specimen. It has not been possible, to date, to match specimens with two of his types, and though they probably represent valid species their relationship to other species will remain uncertain until at least the opposite sex is found.

An amusing example of Bruner's fear of losing an opportunity to name a species may be seen in his Biologia Centrali-Americana work of 1908 where he reports two females from Costa Rica and Honduras under the name of *Cylindrotettix insularis,* a species he had previously described from Trinidad. He made a few descriptive comments on these specimens and then remarked that perhaps these specimens were distinct, and for them he "suggested" the name *C.herbaceus.* I have been unable to distinguish these females from *C. insularis*, but males from Panama and northern Colombia prove to differ slyghtly from the Trinidad species. I have recognized these as a subspecies of *C. insularis* and have used Bruner's name, even though we cannot be certain of the identification of the type until males from Costa Rica are found. It is just such casual and useless work that causes confusion in nomenclature and is certainly quite unacceptable today.

I would comment briefly on the application of various levels of taxonomic catagories. There are presently seven recognized genera in the tribe *Leptysmini.* Two of these, *Cylindrotettix* and *Leptysmina,* which include 14 and 4 taxa, respectively, are distinct clusters of species and easily defined. The genus *Stenacris* includes 9 taxa and forms a moderately diverse cluster of species and have only a few unique characters that distinguishe them from other genera. The genus *Leptysma* includes a very diverse cluster of species, but they still seem more related to each other than to any of those of other genera. The remaining three genera include one to three species each. Two of these I have

considered placing in the genus *Stenacris*. The third genus is one of those names based on a unique male specimen and until females are found its affinity will be uncertain.

At first, I felt dissatisfied with the generic treatment of the tribe, especially upon looking for the reasons given by authors for erecting most of the genera. Then I realized that one could cluster the species into various generic arrangements depending on which set of characters was considered to be the more important. For example, one could emphasize the importance of the ovipositor valves, or the male reproductive structures, or the length and shape of the fastigium, or a combination of two or more of these and other sets of characters. This could result in a variety of generic classifications. Considering the genus *Cylindrotettix* a cohesive cluster of species and the genus *Leptysma* a diverse cluster of species, it became evident that to subdivide *Leptysma* to make it more comparable to *Cylindrotettix* would result in a series of genera containing one to three species in each. I finally concluded that the existing classification did not violate the relationships and therefore I decided to leave well enough alone, inconsistent as it might be.

Looking to the future I strongly recommended the following: comprehensive reviews or revisions of the various untreated groups of grasshopper be undertaken as soon as possible to establish a sound basis for the identification of species and the application of valid names. Such revision should consider all Neotropical species related to a group since some species range from Mexico to Argentina.

If a species clearly shows geographical differentiation the use of the subspecies category is urged in order to indicate close relationship and an allopatric distribution. If the significance or extent of the variation is at all doubtful it is preferable to treat it simply as a variable character of the species rather than naming the variation and possibly causing confusion or difficulty in future identifications.

The correct identification of holotypes is essential to a stable nomenclature. All holotypes bearing a valid name that might conceivably be related to the group being studied should be investigated. Unless a holotype has been examined by a specialist familiar with the diagnostic characters of the group, it should either be reexamined or critical information about it should be obtained to assure its identification. If the holotype cannot be identified with certainty because of its sex or other cause, then it is suggested that it be arbitrarily identified choosing the most likely species, providing it will not displace some long-established name. It is well to state the rationale for any such arbitrary identification in the hope that no one will be tempted to make a change in the future.

Finally, I would urge a rethinking of our conventional format of defining or describing a species. It would seem that the most important objective is to enable a person not familiar with the group to identify the species easily and accurately. A look at popular field guides on birds and other animals suggest that a good illustration, approximate geographical distribution, notes on the critical diagnostic characters, and mention of any other significant or peculiar features of the animal is the information most needed. I suggest that these four items be put in the forefront of any systematic treatment of a species. This information pertaining to the identification of the species can them be followed by information on the nomenclature, important bibliographic references, recording of specimens and related data, some comparative description, relationships, etc. The most important consideration should be to present the important diagnostic information where it can be easily seen and avoid cluttering the paper with lengthy descriptions of dubious value. There can be no set pattern or format for the treatment of species. So much depends on the state of our knowledge of the group. One

should bear in mind that illustrations, comparative tables of characters, and keys with ample references to figures are far more useful for identifying species than any written descriptions can be. I would like to see descriptions limited to comparative descriptions or descriptions of structures known to be diagnostic for related species. I recommend as an educational exercise taking a series of unidentified specimens from some tropical area where the fauna is not well known and of a group with which you are not familiar and attempt to identify them with the literature on the group at hand. I believe it would be immediately apparent how the format of the papers could have been improved to simplify the task of identification.

I have perhaps been overly critical of the authors mentioned due to the troubles they have caused me in the systematic treatment of the Leptysmini, but there is no doubt that these authors have made many substantial contributions to the systematics of the Orthoptera. I believe a little self criticism can help all of us, and I can only hope that I myself will not be responsible for too much confusion in the future.

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DNA CONTENT IN SPECIES BELONGING TO THE FAMILIES ACRIDIDAE, OMEXECHIDAE, ROMALEIDAE (SUPER–FAMILY ACRIDOIDEA) AND PROSCOPIIDAE (SUPER–FAMILY PROSCOPOIDEA)*

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INTRODUCTION

There are in the literature few papers concerned with the DNA content in the orthopteroid insects. One of the work on this subject come from John and Hewitt (1966). According to them, the karyotypic stability assumed for the species of the family Acrididae in studies made on chromosome number and structure is not true when the amount of DNA of spermatid nuclei are taken on account.

In this opportunity is our intention to study the DNA content of the followings species: *Rhammatocerus conspersus, Metaleptea brevicornis, Xyleus sp, Aleuas gracilis, Omexecha servillei* and *Cephalocoema borelli.*

Rhammatocerus conspersus, Metaleptea brevicornis and *Xyleus sp*, likewise the majority of species belonging to the family Acrididae have a karyotype with 2n (♂) = 23 acrocentric chromosome that is considered basic for the Cryptossacci. In *Aleuas gracilis* the occurrence of two centric fusions has modified this basic karyotype. One of the fusion took place between two autosomes and the other between the sex chromosome and an autosome. The first one gave raise to a large metacentric autosome and the second has changed the XO (♂); XX (♀) sex mechanism to a Neo XY (♂) type. As a consequence, the diploid chromosome number was reduced from a 2n (o) =23 to 2n (o) =20 (Ferreira, 1974, 1975). *O. servillei* has a karyotype with 2n (♂) = 23 (Piza, 1952; Saez, 1956; Mesa, 1956 e 1963; Ferreira, 1974). Save the largest pair of autosomes that is metacentric, all the others, even the X are acrocentric. *Cephalocoema borelli* has 2n (♂) = 19 acrocentric chromosomes (Ferreira, 1974).

With the data here obtained the DNA content of species belonging to different families, as well as the DNA content of species belonging to the family Acrididae may be compared.

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MATERIAL AND METHODS

The species here studied as well as their collecting localities are listed below.

1. Super family Acridoidea

   Family Acrididae

   Sub family Copiocerinae

   Aleuas gracilis Stãl - Corguinhos, Mato Grosso, Brasil.

   Sub family Gomphocerinae

   Rhammatocerus conspersus (Brunner) - Corguinhos, Mato Grosso, Brasil.

   Sub family Acridinae

   Metaleptea brivicornis (Blanchard) - Corguinhos, Mato Grosso, Brasil.

   Family Romaleidae

   Sub family Romaleinae

   Xyleus sp (Ilha Solteira, São Paulo, Brasil).

   Family Omexechidae

   Omexecha servillei (Blanchard) - Rio Claro, São Paulo, Brasil.

2. Super family Proscopoidea

   Family Proscopiidae

   Cephalocoema borelli (Giglio-Tos) - Corguinhos, Mato Grosso, Brasil.

Spermatids nuclei were chosen for the DNA measurement because they are easily identified and have the chromosome material uniformily distributed in it. The testes removed from the males were cleaned of the investing fat body and fixed for 12 hours in Carnoy 3: 1. The fixed material was hydrolysed in NHCl at 60º C during 8 minutes and transfered to Feulgen reagent for one and a half hour. The Feulgenized material was bathed in tap water and finally lightly squashed. The testes of all the species received the same treatment, i, e, fixation, hydrolyse and staining were done at the same time and with the same stock solution.

The DNA content per nucleus in arbitrary units was determined according to Frazer and Davidson (1953). All the extintion values were taken in a Zeiss citophotometer at the wavelength of 560 nm for each of 10 nuclei from 3 individuals in each specie. The extintion value for each nucleus was the mean of three values obtained at three different plugs. The values of the DNA content obtained for each species were arranged in histograms (Fig. 1).

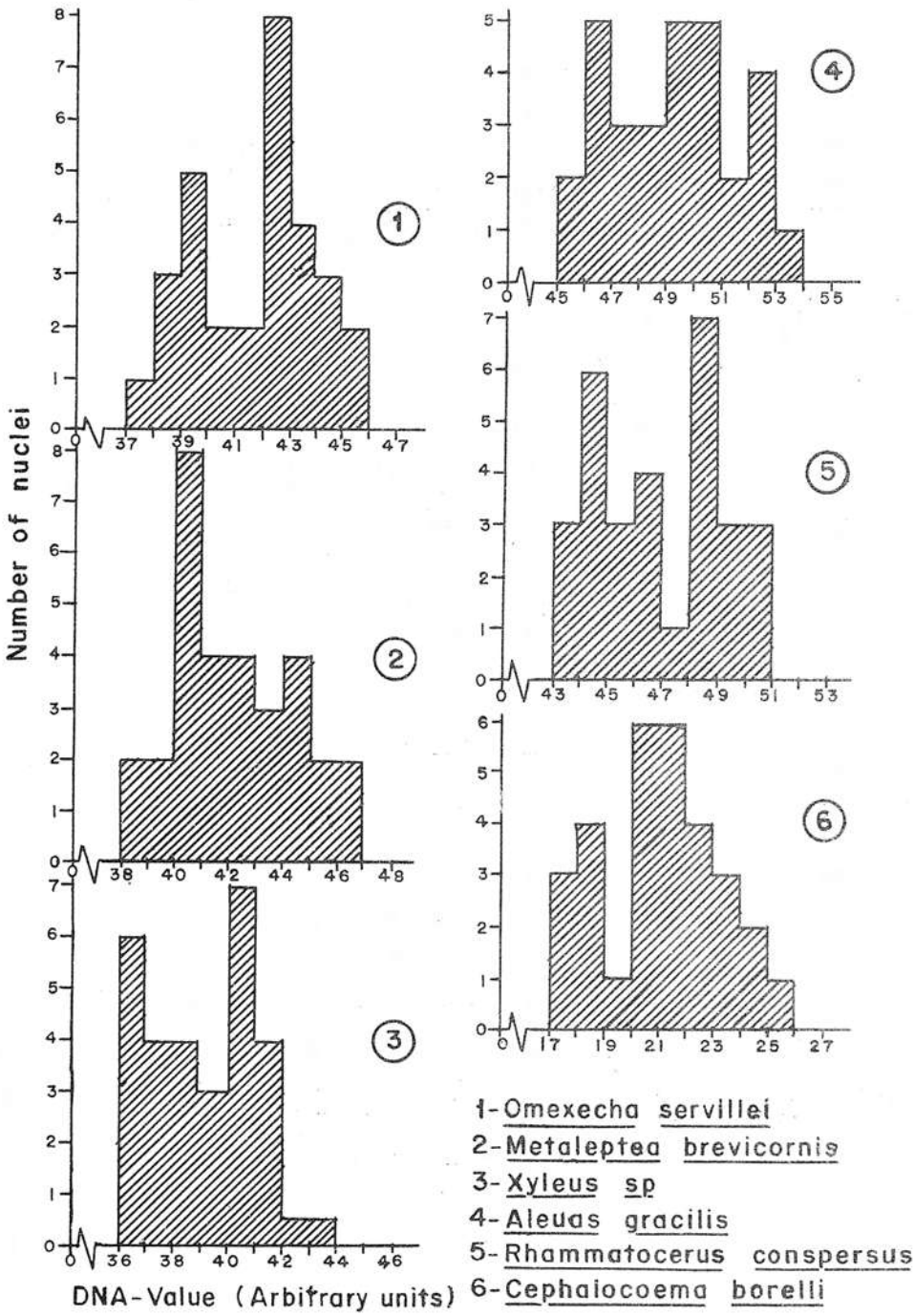

Fig. 1 – The DNA content (in arbitrary units) of 1C spermatid nuclei in 6 species of orthoptera (3 species of Acrididae, 1 specie of Romaleidae), 1 specie of Omexechidae and one of Proscopiidae). E ach histogram is based on 10 nuclei from each 3 individuals. The total number of nuclei measured per species is 30.

RESULTS

The analysis of variance of the DNA content (Table 1) obtained photometrically in spermatids nuclei shows that no significant differences exist between individuals of the same specie but significant differences were observed between species belonging either to the same, or to different families.

TABLE 1. **Analysis of variance of the DNA content in 5 species of the Super Family Acridoidea (belonging to three differents families) and one of the Super-Family Proscopoidea.**

Source of Variation	df	SS	MS	F
Specie	5	15.007.6760	3001.5352	1762.1882 *
Individuals in the specie	12	20.44	1.7033	0.3185 n.s.
Residual	162	86.664.830	5.3487	
Total	0.05	15.894.5990		

* = significant

n. s. = no significant at 0.05

The Tukey test (Table 2) shows that there are significant differences in the DNA content in most of the species. Howewer no significant differences were observed between *Omexecha servillei, Metaleptea brevicornis* and *Xyleus sp* and also between *Aleuas gracilis* and *Rhammatocerus conspersus.*

TABLE 2. **Tukey test aplied to cytophotometric data; bars conect species not differing significantly at the 5% level.**

Specie	Family	X DNA
Omexecha servillei	Omexechidae	41.39
Metaleptea brevicornis	Acrididae	42.03
Xyleus sp	Romaleidae	39.26
Aleuas gracilis	Acrididae	49.00
Rhammatocerus conspersus	Acrididae	47.03
Cephalocoema borelli	Proscopiidae	20.93

Only two of the species of Acrididae with similar karyotypes show no significant difference in DNA content (Table 2).

DISCUSSION

The results of DNA content obtained cytophotometrically in species of the family Acrididae with similar karyotypes show that chromosomal rearrangement not detetable at chromosomal level ocurred in these species during the philogenetic process, since significant differences in DNA content was observed between them. Similar results were obtained by John and Hewitt (1966). The nature of these chromosomal rearrangement is unknown at the moment, but the most probable hypotesis is concerned with the occurrence of duplication or dificiency (Rees and Jones, 1967).

In spite of the great chromosomal rearrangement that has modified its karyotype (Ferreira, 1974, 1975) *Aleuas gracilis* has a DNA content not significant different from *Rhammatocerus conspersus* that has a karyotype without any aparent change in its organization. The similarity of DNA content observed in *Omexecha servillei* in *Xyleus sp* and in *Rhammatocerus conspersus* seems to shows a close phylogenetic relationship between the families Acrididae and Omexechidae thought more species should be studied. This point of view is in according with the cytological data. Mesa (1963, 1964) has claimed that the basic karyotype of the family Omexechidae is secondarely derived from the 23 acrocentric chromosomes normally found in the species of the family Acrididae by a pericentric inversion in its longest autosomes.

Cephalocoema borelli, the single species of the family Proscopiidae here studied, has approximately half of the averaged DNA content found in the remaining five species, which belongs to the families Ommexechidae (1 sp), Acrididae (3 sp) and Rommaleidae (1 sp). Thought fragmentaries, since more species shoul be taken on account in future studies our observations seems to show no close relationships between Proscopiidae and the above mentioned families. Also from the citological point of view the species of the family Proscopiidae depart from the classical $2n = 23 - 24$ of the true grasshoppers. In fact, according to several papers published (Piza, 1943, 1945; De Castro, 1946; Dasgupta, 1960; Santiago, 1968; Mesa, 1973; Ferreira, 1974), de most common number in Proscopiidae is $2n = 19\text{-}20$, with all the chromosomes acrocentric. In a few species (Mesa, 1973 and Ferreira, 1974) this karyotype has been modified throught several structural rearragements. The above mentioned observations agree with the recent point of view of Kevan (1966) and Blackith and Blackith (1966 1967 a and 1967 b), that based on morphological considerations removed Proscopiidae from Acridoidea. The authors placed it on Eumastacoidea and recently Descamps (1973) studyng the phallic complex of species belonging to 9 genus from the 14 already known created the Super-family Proscopoidea with a single family Proscopiidae that possess all the species described.

SUMMARY

The total DNA content of *Aleuas gracilis, Rhammatocerus conspersus, Metaleptea brevicornis* (Family Acrididae), *Xyleus sp* (Family Romaleidae), *Omexecha servillei* (Family Omexechidae) and *Cephalocoema borelli* (Proscopiidae) were determined citophotometrically in nulcei of spermatids.

The results obtained have shown mainly that: a) species with the same karyotype may have significant differences in the DNA content; b) the family Omexechidae seems to be closely related with the families Acrididae and Romaleidae, and c) the family Proscopiidae has approximately half of the DNA content found in the species of the families Omexechidae, Acrididae and Romaleidae.

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ACRIDIDAE OF RANGELANDS IN EASTERN KANSAS

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Grasshoppers are among thee most destructive insects in Kansas. Severe outbreaks were caused in the state by the so-called Rocky Mountain grasshopper, *Melanoplus spretus,* now extinct, which periodically destroyed much of the Great Plains crops. *M. spretus* was a truly migratory species. Its severest damage in Kansas occurred intermittently during the period 1846 through 1877, the worst in 1874.

Other major outbreaks, involving other species, were in 1913 and in 1936 and 1937 near the end of several severe drought years with high temperatures. A moderate outbreak in southeastern Kansas in 1953 moved locally westward,taking several years to reach by the west state line. Another series of outbreaks may be forthcoming; grasshoppers appeared locally in 1976 in southeastern Kansas and certain other areas, after 2 or 3 years of drought.

Smith (1954), summarizing grasshoppers in Kansas, 1854-1954, arrived at certain conclusions, including: grasshoppers increased in dry years as shown by the population the next year; outbreaks followed 2 successive years of sub-normal rainfall; populations were generally low in years when rainfall was above normal in a given summer and the next year; no clear correlation was discernible between total precipitation during six summer months and numbers of grasshoppers; cool, damp periods in June and July resulted in an epidemic of "diseases" that appreciably reduced grasshoppers; no significant correlation between mean annual temperatures and populations was discernible; in general, populations peaked at intervals of 4 to 6 years and were lowest at intervals of 6 to 8 years; while the numbers each year must be dependent in some way on the kind, amount, and quality of natural food available, modified directly by the weather as from dashing rains and by extreme temperature, and indirectly as weather affects plants, parasites, predators, and diseases, the data available on food do not permit a correlation to be made with populations; predators, parasites. Diseases affected numbers both in the current and succeeding years of major attacks; results of heavy killing by diseases were sometimes discernible in years after cool, damp summers. Dr. Smith's sources of information were based more on cropland than rangeland grasshoppers, and little information was available for most of the 100 years.

REV. SOC. ENT. ARGENTINA, Tomo 36 (1-4): 41-44.

Since then, the chlorinated insecticides that were so effective now are either banned or in the process of being banned, as are some other insecticides.

From 1960 through 1970, a Cooperative (North Central States) Regional Project, "Factors Influencing the Distribution and Abundance of Grasshoppers", was funded by the U. S. Department of Agriculture and certain State Agricultural Experiment Stations. No serious, widespread outbreaks occurred during those 10 years. The project was directed toward more fundamental studies rather than insecticide control under emergency conditions. Primary participants were Kansas, Nebraska (the next State north) and North Dakota, which borders Canada. Among the findings were: populations among species fluctuated independently, with highest positive correlations among species not concurrently competing for the same habitat or food, despite sufficient space and food for all; grasshopper species in the same habitat and with similar food requirements had different population cycles, indicating they also were influenced by other environmental factors; good range management practices tended to stabilize grasshopper populations but did not necessarily eliminate them as competition for range forage. A detailed analysis of the feeding preferences, selectivity, and forage damage potential for North Dakota, Nebraska, and Kansas has been published (Mulkern *et al* .1969).

The present report covers in part grasshopper studies of grassland and rangeland in the bluestem grass strip, often called the "Flint Hills", which constitutes a north-south strip of 4 million acres (1.6 million hectares). Immediately east is the bluegrass strip, and west is the bluestem-short grass strip. Comparatively little is known about the grasshoppers of rangeland because rangeland is a relatively low income crop and damage is less apparent than in row crops.

Rainfall decreases from about 40 inches per annum in southeastern Kansas to 18 inches in the western portion. Until recently, it could be stated that short grass prairie replaces forest and tall grass prairie, from east to west. But thousands of hectares have gone into irrigated corn (maize) in western and central Kansas. To date, no substantial populations of grasshoppers have developed in the newly irrigated areas, but, based on studies in eastern Kansas, mixed forb-grass feeders such as *Melanoplus bivittatus* and *M. sanguinipes* can move from grasslands to cultivated crops and *vice versa.* Others like *M. differentialis* are seldom, if ever, found in pure grassland or rangeland but will surely move in from weedy field margins.

Our studies have been conducted primarily near Manhattan, Kansas, where precipitation averages 33 inches a year.

Melanoplus confusus Scudder and *Melanoplus bivittatus* (Say) matured on western ragweed, *Ambrosia psilostachya* D. C. but neither attained more than the 4th instar on Louisiana sagewort, *Artemesia ludoviciana* (Nutt, T. & G.). *Melanoplus keeleri luridus* Dodge matured on *A. psilostachya* and western yarrow, *Achillea millefolium* L., but it attained only the 4th instar on Louisiana sagewort. Development to adult was 12 days longer among early-season-collected first instars than among those collected 30 days later; both temperatures and current stage of development of the host plant were influencing factors. *Hypochlora alba* matured on Louisiana sagwort but attained only the 3rd instar on western ragweed. Development times in all but the 4th instar of the 3 species surviving on western ragweed differed significantly.

Other studies (Campbell *et al* 1974, Knutson and Campbell 1976) generally indicate that: (1) the more available a favorite hostplant is, the more readily it is ingested, and the larger the grasshopper population; (2) grasshoppers inhabit the Loamy Upland and Clay

Upland Range Sites about equally, and considerably more than the Limestone Breaks Range Site; (3) populations decrease when burning is delayed during the early part of the growing season; and (4) populations increase as cattle-grazing increases.

Our current field insecticide evaluations involve Latin squaredesigned mini-plots, each replicated 4 times, in rangeland. A 12-inch high metal shield surrounds each plot to minimize nymphs jumping from one plot to another. We are evaluating both legally approved and experimental insecticides, including pyrethroids. Plots contain about 7 to 14 principal plant species, primarily grasses; and 12 to 16 additional species of forbs. Basal ground cover varies from 4 to 15 o/o; plants average 4 inches high. There are 12 to 14 grasshopper species in the plots. Mortality is recorded daily for several days. Additionally, glass boxes, 6" x 6" x 9", are sprayed on the inner surface while containing 10 grasshopper specimens. The box is then covered with cheesecloth. Behavior response, morbidity, and mortality among species of nymphs and insecticidal treatments are recorded for several days (I. Javadi, leader).

The so-called "Pest Management" approach is widely acclaimed, and practiced with some crops in the United States. As is well known, it should involve using a certain control or suppression measure (s) at the right time and intensity and only when needed, as determined by the economic threshold (when the insect population is sufficiently damaging that control measures should be initiated). Among the factors to which we have devoted special attention are: (1) species that are beneficial or at least neutral because they feed on grasses or forbs of little or no value to livestock so no control is needed; (2) recognizing young instars early so they may be suppressed while still in a small area where egg pods were laid, so relatively little insecticide is needed; (3) determining seasonal history from hatching until the females lay eggs; (4) relationship between rangeland management procedures and grasshopper populations; and (5) evaluating pyrethroids and other approved and experimental insecticides to replace the now-prohibited insecticides, taking into consideration relative effects among species and instars within species.

We plan to continue studies of antibiosis. Both behavioral and biochemical approaches are emphasized.

We will continue to expand illustrated keys to the grasshoppers of Kansas, with more details on variation within species, separating close-appearing species and sexes, and recording micro-habitats and detailed seasonal histories.

We shall attempt improved evaluation of the extent of loss, particularly when grass and other plants are tall and close together. Although we know whether or not a certain plant species is ingested, we do not know, for example, how much is ingested, or whether the leaf is nibbled at the tip or at the base, which could sever the entire leaf. In our study area, grasshoppers generally hatch after the plants are well along in spring growth, so moderate feeding as the plants mature may be beneficial by pruning. Furthermore, some species are reported to change to more succulent hostplants as initial plant(s) ingested become drier, but we have not observed such switch-overs to any extent in our studies.

From a practical standpoint, during a year of good growth grasshopper feeding may cause little or no noticeable loss, while during droughts their feeding damage may be visibly extensive with no increase in grasshopper population. Many other factors may be involved: they may feed closer to the ground than livestock do, thus destroying the growing tips; soil erosion may follow denuded areas; grasshoppers may be irregularly distributed in a field, even when favorite hostplants are present.

Hence, mere counts per square yard are not valid, although they probably now are the best practical method in our state where the grasshopper species-hostplant relationships are known. Vegetation plays an important role beyond providing food: its height and desity, for example, both influence the size and incidence of open spaces. Unpredictable weather is highly important.

We are attempting to improve methods of measuring grasshopper density. High vegetation limits the value of sweeping because practically no nymphs are taken. Bottomless cages have been placed when grasshoppers are inactive so they may be counted in daytime. Quick traps that suddenly release a trap onto an area of known size are used, as are vacuum hoses to suck up all insects (and some dirt and small stones). A detailed knowledge of grasshopper habits is important in population surveys. The survey must take into account which species fly, which remain motionless or "frozen", which crawl to opposite sides of stems, and which burrow into debris or cracks in the ground. Such behavioral studies are being conducted at the Konza Prairie Site.

When based on 16 years' records of grasshopper populations, such as we have amassed, a model and preparation of a Dest management approach may be feasible for grasshopper species. But we will still lack, among other things, data on predators, parasites, and disease. Knowledge of development of grasses resistant to grasshopper attack, still in its infancy, would help such a pest management program.

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ABSTRACT

INTERACTIONS BETWEEN SPECIES WITH PARAPATRIC DISTRIBUTIONS: A CASE IN *BARYTETTIX* (ORTHOPTERA: ACRIDIDAE: MELANOPLINAE)

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Surprisingly little is known of the actual edge of the range of most orthopterous. At least one study of the contact zone between related species has led to a new theory of speciation (stasipatry, White *et al*, 1967), and I suspect that further studies will reveal other biological situations which cannot be fully explained by current theory. Such a case has been worked out in the genus *Barytettix* (revised by Cohn & Cantrall, 1974), a short-winged melanopline occurring in northwestern Mexico and southwestern United States.

Barytettix h. humphreysii (Thomas), with a wide distribution in western Sonora and southeastern Arizona in desert, desert grassland and thorn scrub habitats, is in parapatric contact with B. *b. cochisei* Gurney, which occurs in similar habitats mainly in eastern Sonora and southeasternmost Arizona. Six intensive transects have been made across the zone of contact and surveys have been made in several other areas near the probable contact zone. These collections suggest that the two forms are in contact or within breeding range for the entire length of their ranges, a distance of about 500 km. Nowhere have the two forms been found together or one within the range of the other. In each of the transects hybrid populations have been found forming a cline between the two parental types. The hybrid zone is invariably less than 10 km, an unexpectedly narrow zone for such active and abundant grasshoppers.

The hybrid nature of these populations has been confirmed by their similarity to laboratory produced hybrids in seven diagnostic aedeagal characteristics. Analyzed by hybrid index technique, the hybrid populations show more variation than adjacent parental populations. Individuals in the middle of the zone sometimes show a mixture of parental characteristics, but most are, to a large extent, intermediate, and no pure parental types are found there. These same characteristics of hybrid zone populations are found in the north in Arizona at 1700 m. in elevation, and far to the south in Sonora at 200 m. There is some leakage of one or two characteristics beyond the zone for short distances.

Current theories of speciation do not account for this situation. 1) If *cochisei* and *hymphreysii* are species and hybridizing only in hybrid habitats, then they should overlap somewhere along the contact zone. No such overlap has been found, nor is the habitat in

the known hybrid zone obviously intermediate. The two forms seem to occupy generally similar habitats in nearby areas. 2) The situation might represent a case of recent contact between two previously isolated demes, the two now completing the development of reproductive isolating mechanisms. Under this interpretation it is difficult to understand why the characteristics of the hybrid zone populations are similar in both Arizona and Sonora separated by distance of 500 km, and at both high (1700 m) and low (200 m) elevations. Somewhere in this long zone the contact must be older, or habitat differences might produce different rates of speciation. Either would result in different kinds of populations in the zone of contact, some of which should contain parental types. 3) The same problems are encountered with the interpretation that the two forms are now merging after initial isolation. Variation in the width of the hybrid zone correlating with different habitats and different time of initial contact would be expected but is not found. 4) Finally, stasipatric speciation does not seem to apply. We have been unable to find any chromosomal isolating mechanisms. Completely hybrid, as well as backcross, populations are common in the hybrid zone, and one has been in existence for over 50 years. This contradicts preliminary evidence that our laboratory F_1 hybrids are sterile or cannot mate.

This case of hybridization between *Barytettix h. humphreysii* and *B. h. cochisei* demands a new theory of species interaction.

RECENT DISCOVERIES IN THE SEASONAL BIOLOGY AND INFRASPECIFIC SYSTEMATICS OF *LOCUSTA MIGRATORIA MIGRATORIOIDES* (R. AND F.) AND THEIR BEARING ON CONTROL STRATEGY AGAINST MIGRATORY PEST ACRIDIDS IN THE TROPICS.

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The study of seasonal variation of all kinds is vital to our understanding of the nature of the species and subspecies in many acridids. Museum collections are usually inadequate to such studies, though preliminary clues to such things as seasonal migration may occasionallly be inferred, *e.g.*, as in *Ochrilidia* (Gomphocerinae) (Jago).

In recent years attention has been focussed on seasonal variation because many acridid pests are multivoltine. Their mobility as adults has led to taxonomic and biological problems in defining the nature and extent of the breeding populations. Among mobile acridids *Schistocerca gregaria* (Cyrtacanthacridinae) is probably the only species sufficiently well monitored in the past for us to be able to define the breeding population. Once the factors underlying population dynamics and morphological variation are understood, however, the applied question of control strategy becomes easier to solve. The extent of monitoring networks for the mobile pests can be estimated and the intensity and kind of observations necessary determined.

Systematics and taxonomy of mobile acridid pests have received more emphasis at C.O.P.R. recently because it is increasingly recognised that they offer problems akin to those thought to be unique to the large locust species in the past. They show clear phase characteristics in many cases and are often variable and cause large crop losses in the course of their extensive migrations. Mr. J. M. Ritchie is revising *Oedaleus* and *Gastrimargus* (Oedipodinae) because of their economic importance, while *Aiolopus* (Acridinae) was recently revised by Mr. D. Hollis (1968). My colleague Mr. G. Popov is currently investigating the seasonal dynamics of *Oedaleus senegalensis* and *Aiolopus simulatrix* in Mali, Niger, Haute Volta, and Nigeria. Dr. R. C. Rainey (1976) and Dr. J. Riley at C.O.P.R. have demonstrated nocturnal flight in grasshoppers, the insects flying at heights between 3000 and 5000 feet.

In this short talk I would like to discuss aspects of the population dynamics of *Locusta migratoria migratorioides* in Mali.

I should acknowledge at the ontset my indebtedness to the UNDP/FAO Special Fund project which attempted to formulate a more economic strategy of forecaste and preventive control for O.I.C.M.A.. I was fortunate to be associated with the project and O.I.C.M.A. between 1971 and 1975, enabling C.O.P.R. to look at isoenzyme and chromosomal variation in field populations of the locust within the framework of the monitoring system set up by counterpart African scientists and visiting experts. Some of our dashed assumptions may offer food for thought.

DAILY DYNAMICS OF POPULATION STRUCTURE

Daily samples of male *Locusta* were collected in 1973 (July - August) and 1974 (September - November) at two localities on the Niger flood plain in Mali. In this I was greatly assisted by Ms. P. M. McAleer of C.O.P.R. and the station staff of O.I.C.M.A. This frequency of sampling is not normally practiced as routine by O.I.C.M.A. For purposes of control the Organisation had simply developed three adult categories - very young soft fledglings (JJ), hardened but sexually immature adults (J), and old adults (V). Cuticle slice techniques (Neville, 1963c) enabled us to define the aging of 1 day up to about 20 days post fledging. A number of points emerged:

(i) superficial appearance based on softness of cuticle was not always an accurate assessment of age. Thus, adults older than 6 days post fledging may still have thin cuticles and be classified as JJ though actually J.

(ii) there was a tendency to sample more green forms in am. samples than in pm. samples. This kind of bias has been noted previously by Nankivell (1974) who was able to show that insects caught in the heat of the day tend to show certain chromosomal inversions absent in those caught at cooler periods. For uniformity and standardisation all population sampling should take place at equivalent times of the day.

(iii) population development in hoppers and adults was not smooth but evolved in a series of waves, intervals of time between peaks of Vth. instar hoppers and young JJ fledglings being in conformity with the findings of earlier workers like Davey (1956), Descamps (1961), and Farrow (1972). The regularity of this pattern of events was broken by dramatic meteorological phenomena such as a period when light day rains were replaced by torrential night rains. At this time there was a dramatic influx and exodus of J adults and fledging ceased subsequently perhaps due to high mortality among late instar hoppers. The massive influx of J adults was associated with a shift of the winds from the SW to E and SE in the vicinity of storms.

(iv) Field samples showed a bias toward low numbers of 1-3 day old insects. The reason for this is not understood. Absence of older age groups in samples may be due to exodus. Our observations in 1974 at Kara were continuous from August to November. Although the area was flooded from 8 September to 29 October the profile of age groups present remained the same with low levels of adult fledging. This may have been due to survival of hoppers on emergent "togueres" of hillocks. Thus, although the region became theoretically uninhabitable due to flooding, population structure remained stable. As floods receded in November there was a shift towards the older age groups. We can conclude that Kara, being rather centrally placed in the flood plain, was a transit area for mobile adults for nearly three months. This would be difficult to detect without the aging technique we adopted.

(v) Ms. McAleer visited a northern lake shore habitat in early October 1974. Here were two adjacent populations of *Locusta,* a solitarious one in lake bed millet fields and a "transiens" population in rapidly dessicating natural grasslands on sandy soils alongside the lake shore. An analysis of age groups showed that there was a large night exodus in "transiens" adults of age 10-13 days post fledging. The solitarious populations of the lake bed showed no such exodus. Clearly closely adjacent populations were affected by suitable night flight conditions in an entirely different way. The important factor here seemed to be phase status of the two populations. The transiens insects underwent a coordinated mass departure. The solitarious populations behaved like those at Debena in 1973 and either had no incentive to exodus or were prone to uncoordinated departures by single insects older than 5 days post fledging age.

This set of observations shows us that phase behaviour cannot be ignored in assessing the potential for dispersal by acridid populations. Meteorological data on its own cannot tell us whether dispersal will take place or the biological impetus of that dispersal. This is often forgotten in the attempt to build models based on physical parameters.

Dr. W. Muller (1975 a, b, c, d), the consultant agrometeorologist to the UNDP/FAO project, has questioned the hypothesis that the ITCZ is the most important element in triggering flight and concentrating *Locusta* populations. The project carried out one marking and recapture exercise using fluorescent dyes delivered from ULV attachments on a Jetranger helicopter. As in the observations of Dr. Lecoq in Madagascar (1975) the scatter of recaptured adults indicated a general downwind displacement relative to the seasonal prevailing wind but some apparent upwind movement by an appreciable minority of adults. Storms tracked through the flood plain area by Dr. Muller took a generally north-west from south-east path. Results from routine station monitoring over the period of 1973 showed that influx adults occupying virgin Sahelian oviposition sites at Dioura, on the western edge of the flood plain, may well have arisen from newly fledged adults in areas to the east of Dioura. It is also clear that much of the monthly dispersal activity takes place in areas far removed from the mean monthly position of the ITCZ (as measured at ground level), though it should remembered that daily oscillations of the front may entail shifts over several hundred kilometers. The importance of the ITCZ in concentrating nocturnal flights of solitarious *Locusta* adults was not elucidated by the Project in Mali.

CHANGES IN CHROMOSOMAL CHARACTERISTICS

During 1973 an effort was made to study isoenzymes collected from live field insects of both sexes in Mali. These had to be isoenzymes capable of being collected in Mali and being transported to London without deterioration. Originally it had been hoped that esterase isoenzymes from muscle extracts might be used to characterise different populations within a given generation and aid in the study of migration (Curry, P. J.). It had already been noted in the laboratory that domesticated insects quickly showed reduced esterase activity compared with field insects, 8-10 bands being common in laboratory insects while field insects showed a maximum of 22 bands. Analysis showed that there was little or no regional difference in field material but that considerable differences were detectable between samples of different generations. Data was therefore pooled to give better statistical results in our analysis of inter-generational differences. Polyacrylamide gel analysis showed that some 33 phenotypes could be commonly detected and that these fell into 7 groups according to location on the gel and staining characteristics. Group F was remarkably constant and was used as a reference for correcting measurements of the other band positions. Among the interesting points that emerged:

(i) certain groups of phenotypes were much higher in males of the rainy season generations than in the equivalent females. Mean band number was roughly equal in males and females of the dry season retreating floods generations. Sexual disparity was highest in E group phenotypes in the P1 generation.

(ii) B group phenotypes became much lower during the rainy season generations in both sexes; G group phenotypes were more frequent in the rains than in the retreating floods generations. High activity D group phenotypes occurred at low frequency during the P2; A group high activity bands were lower in the P1 than in the D generations and still lower in the P2.

These results clearly complicate the use of esterases as a taxonomic tool and pose fascinating questions as to the significance of reduced enzyme activity during the P generations.

ISOENZYME DYNAMICS IN *LOCUSTA*

All *Locusta migratoria* males so far examined, from populations in Majorca, Mali, Nigeria, Saudi Arabia, and Australia, have a normal complement of $2n♂ = 23$

chromosomes supplemented in some or all follicles by cells containing extra chromosomes - B or supernumerary chromosomes. These may be 2, 4, 6, 8, 10 or more in number, cells with higher numbers of "B" chromosomes showing a tendency for nuclear disintegration. All "B"s so far examined in *Locusta* have been paired.

Carefully synchronised laboratory stock at C.O.P.R. showed a steady increase in chromosome numbers and chiasma frequency with age. This tendency is also seen in field populations, not readily for reasons probably related to the complex influx and exodus of elements in the population. Field studies of chromosome number and chiasma frequency were initiated after a chance monitoring of adults during the passage of an isolated rainstorm at the beginning of the dry season in 1972. Samples of male testis tissue showed an intriguing change in chromosome characteristics, though the causative factors were far from clear. The month of observations in 1973 at Debena did not give decisive answers to our questions. At that time it had been assumed that the most interesting results would be obtained by sampling at several stations rather than sampling cotinuousy at a single spot. Later collections were pooled so that it was not possible to link an chromosome counts to adults of a particular age. In 1974 the Kara sampling showed that populations were in a state of dynamic flux.

It is hoped that an area in which pure exodus is in progress, with little or no influx of J adults with one or more nights of dispersal flight to their credit, will be found in 1977 or 1978, and further studies are to be made in cooperation with Dr. G. M. Hewitt at the University of East Anglia.

Chromosome studies have shown that in *Schistocerca gregaria* the diplotene chiasmata were created some 5 days earlier (Henderson, 1966). Moreover, temperature rise causes decrease in chiasma frequency. When we count the chiasmata we are looking at an impression of events to which the insect was subjected some 5 days earlier. Control of testis temperature in acridids is complex. Hot, dry conditions may be better for body temperature control than warm, humid ones simply because in the just case the grasshopper can lower its temperature more easily by evaporation.

It is my belief that Kayano (1971), Hewitt & Ruscoe (1971), and White, among others, have taken too static a view of chromosomal phenomena. The environment and the age of the follicles may have an important role to play in such matters as "B" chromosome numbers. As a taxonomist, I think it would be necessary to play safe in field studies and to compare individuals from the same ecoclimatic background history and of the same age. It is unfortunate that there is a simple "B" chromosome accumulation mechanism from somatic cells to follicle cells, and there is a possibility that too many "B"s causes cells possessing them to be eliminated from sperm production. It is of immense interest that "B" chromosomes have been reported from species which have been subject to population disturbance, either naturally or through the agency of man. Where mobility is essential, the production of "B" chromosomes might be related to competition between production of sperm and mobilisation for dispersal. Extreme emphasis on the latter function may in part explain the lowered fecundity of swarms. We have not yet studied the relationship between "B" chromosome production and age after the first dispersal flight has been satisfied. This aspect may be difficult to study under laboratory conditions.

SEASONAL CHANGES IN FOOD PLANTS EATEN

It is dangerous to assume that in mobile multivoltine species the diet remains stable either in species eaten, quality, or quantity. Availability of a particular set of favoured plant species and the growth status of a particular plant are of paramount importance. Even in relatively immobile species like *Zonocerus variegatus* (L.) (Pyrgomorphidae) in West Africa, a species previously simply classified as polyphagous, only a few of the wide range of plant species eaten are of any major value to sexual maturation and egg

production (Bernays *et al.*, 1975). In some 5 years of study Dr. J. Ohabuicke has studied *Locusta migratoria migratorioides* in Mali (Ohabuicke, 1975). A series of grass species were chosen for testing on laboratory reared locusts from each of generations D1, D2, P1, and P2. Significantly it was found that rank order of the grasses as successful providers of nutrients was the same both for hopper development and for egg production. The latter was measured by ovariole number and red body ratio in females. It was found, however, that using wild grasses the reproductive potential decreased during the D1 and D2 generations and rose during the P1 and P2 generations. Intake also varied seasonally showing that each grass species has a peak of palatability. Analysis of particle fragments in faecal pellets from different generations taken from different ecozones of the flood plain and sahelian habitats in Mali showed the proportion of the different grass species actually available to the insects both temporally and spatially. Incomplete though the study was it is of immense importance in indicating a potential method for assessing the nutritive potential of grasslands forming grasshopper habitats. Only under extreme conditions would such a model become inapplicable, and this when water itself becomes the limiting factor, as it did in recent drought years for *Chortoicetes* in Australia (Bernays & Chapman, 1973).

With a complete examination of the dominant grass species eaten by *Locusta* it would be possible to give them a rank order as providers of minimum hopper mortality and maximum egg production. Analysis of faeces in areas with hopper populations would then give us a means of assessing the future size of the adult population in a given zone. Further, similar examination of adult faeces would give us an assessment of future egg production. The method takes account of changing ecological climax and cycles. It is wrong to assume that a given area will always offer a haven for a species. Thus, in N. E. Bornu province of Nigeria G. Popov reported that on the clay plains south of lake Chad the wild grasses had been replaced by broad leaved plants unsuitable to *Locusta* during the recent drought. Subtler changes in dominant grasses and grass associations must be very important to graminivorous acridids. If onto the hopper survival/egg production map we were to impose the necessary meteorological data, a model for predicting areas of dangerously high population density could be constructed.

MODELS AND FORECASTING; TO FORECASTE OR NOT FORECASTE

A model has been proposed by Launois (1975, Mar.) based on ideas generated as the result of 20 years observations by Dr. J. Tetefort in Madagascar. In Madagascar a claim has been made by Tetefort, Launois, and Lecoq that outbreaks can be predicted in *Locusta migratoria capito* using optimum rainfall and optimum temperature maps. A more complex model was proposed for Mali where, because of flooding, dry season breeding becomes possible. A number of optima were proposed by Dr. W. Muller of the Mali FAO/SF Project which analysed *Locusta* dynamics and their relationship with meteorology over a 26-year period. The optima plotted were as follows:

(i) position of the ITCZ - presumed to have an important role in concentrating adults into areas of pluviometric optima for adult maturation, oviposition, and egg survival. Its position is important also because it is known to be associated with certain pluviometric conditions.

(ii) a scale of average temperature set at 27.5° C + 2.5° C.

(iii) a hydric balance in the soil from −180 mm. to +50 mm., the zero point being of particular importance to locust egg survival and optimum plant growth.

(iv) zones with isohyetes of 80 mm. a month.

Where all these optima coincide would reasonably be assumed to be a zone in which *Locusta* would have the greatest potential for outbreak. Difficulties were admitted in practice when the optima were analysed using real data. The scale of the meteorological

data available is large compared with the size of the outbreak area (the space between isohyetes is large compared with size of the outbreak area). The width of the belt of optima which cross the outbreak area twice a year is wide. Upsurges occur within this rather wide belt, and the reasons for the patchy distribution of high insect densities are not adequately explained. According to Dr. Muller only an average of 75 o/o population variation in a given month in Mali could be explained on the basis of these 4 parameters alone, taken as they were for predictive purposes one month earlier. Note, however, that the nutritional status of the grassland ecozones was not available, and had it been added might have made the model far more efficient for forecasting.

The above account is sketchy, but it is clear that many of our assumptions relating to annual seasonal variation of acridids need to be researched more critically. New methods of forecaste for control of migratory pest acridids and other pest insects will require many more personnel and more financial assistance at the research stage then is required in the operational control which follows. Our current control methods are to varying degrees based on *ad hoc* observations rather than prophylaxis. Control of the Desert Locust has depended on an effective system of scouting and many years of population data related to an insect which lives in a comparitively simple, though enormous, ecological environment.

With *Locusta* we have a pest living in a much more complex ecological system about whose detailed meteorological optima, biology, and past dynamics we know much less. In O.I.C.M.A. the necessary background for a Tetefort/Launoise/Lecoq-type model is still not with us after 26 years of work. The innovation in control strategy suggested by the UNDP/SF project relies on two key facts:

(i) D1 and D2 generations always contain the smallest numbers of locusts, and the populations are concentrated along receding floods habitats which offer better targets for chemical control than the diffuse but more heavily populated rainy season habitats.

(ii) *Locusta* is an insect whose upsurges gather momentum slowly so that increase in a single rains generation cycle of P1 - P2 - P3 is unlikely to cause a major outbreak unless O.I.C.M.A. is lax in controlling D1 and D2 locusts in an exceptionally favourable dry season period.

With other acridid pests in tropical Africa we do not even have the basic data on past seasonal distribution, let alone a sufficient network of stations to build up such a body of information.

At C.O.P.R. we envisage a more comprehensive network of pest monitoring stations in tropical and subtropical zones. How sophisticated such systems become will depend largely on economics and the will to establish such a system. Meetings scheduled for December, 1976, in Rome and sponsored by FAO, may lead to pilot projects covering various major migratory pests which at present threaten the development of viable agriculture in the Sahelian and Sudanic belts of West Africa. One is conscious of being on the threshold of a major step in agricultural pest control. But let us not deceive ourselves by our ability to react more efficiently to sudden disaster into believing that we have a pest forecasting system for tropical acridids. There ir a long way to go before that becomes reality.

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ABSTRACT

ECOLOGYCAL BIOGEOGRAPHY OF NEW WORLD DESERT GRASSHOPPERS

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The Sonoran Desert of Arizona and the Monte Desert of Argentina are floristically similar, both in appearance and in the number of taxa shared. No vertebrates and very few insects display similar disjunct patterns. Similarities in plant communities are therefore partly the result of descent from a common ancestry, while similarities in animal communities are more likely to be due to convergent evolution.

Sonoran and Monte deserts display strong differences in number of species, both at the *alpha* and the *beta* levels of diversity. I have examined the possible causes for species richness differences. The areas surveyed are the Sonoran, Chihuahuan, and Baja Californian deserts and the Monte Desert.

Factors which might determine the diversity of grasshoppers species can be ordered into three major categories: (1) imminent properties of animals and their enviroments; (2) differential extinction rates following widespread colonization episodes, and (3) a balance between species recruitment (achieved through short-term immigration, evolutionary colonization, and speciation) and species loss.

Differences in the heterogeneity of vegetation do not adequately account for differences in the number of grasshopper species between North and South American deserts. Recruitment of species into the Monte may be retarded by extensive mountain barriers and generally poorer source areas. Also, Pleistocene climatic and glaciation events probably affected the Monte more strongly than they did their North American counterparts. The richer source areas of North American deserts may be due both to the greater area and the greater 'heterogeneity' of the North American continent. Ultimately, the differences in faunal richness may be traceable to differences in continental configuration, topography, and latitude, all of which affect climatic and vegetational heterogeneity.

ESTACION DE ALARMA DE NACIMIENTOS DE TUCURAS

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La enorme infestación de tucuras que abarcaba en el año 1954 una superficie estimada en no menos de 10.000.000 de hectáreas, comprendían las provincias de Buenos Aires, Córdoba, Santa Fe, La Pampa y San Luis. Esta situación obligó a los productores y reparticiones nacionales y provinciales de la rama agropecuaria a encarar la lucha coordinadamente y con todos los métodos y medios adecuados disponibles en esa época.

Como complemento fundamental del empleo de los productos químicos y otros procedimientos utilizados en las tareas de control, se debió encarar estudios biológicos de distintas especies para lograr un mejor conocimiento del comportamiento a campo de las mismas.

Además, se consideró de importancia determinar la factibilidad de obtener un sistema de alarma de nacimientos de tucuras. Los trabajos correspondientes se iniciaron a partir de la temporada de primavera-verano de 1958/59.

La iniciativa, el método y su puesta en práctica se debió al aporte conjunto de los Ings. Agrs. Miguel J. Campodónico y Leopoldo Esquivel, en ese entonces técnicos del Instituto de Patología Vegetal del Instituto Nacional de Tecnología Agropecuaria.

Con el transcurso de los años, el sistema se fue perfeccionando y en consecuencia considerándolo un complemento muy valioso en la ejecución de las campañas de control, se elaboró un "Plan de Red de Estaciones de Alarma de Nacimientos de Tucuras", el cual fue presentado y aprobado por la Comisión Central de Lucha Contra las Tucuras en la reunión del 29 de junio de 1972.

El Servicio Nacional de Sanidad Vegetal de la Secretaría de Agricultura y Ganadería de la Nación, en la campaña 1972/73, instaló 21 Estaciones de Alarma las que fueron ubicadas en las provincias de Buenos Aires, Córdoba, Santa Fe, La Pampa y San Luis.

Desde entonces las Estaciones de Alarma han funcionado en forma continuada incluyendo el período 1976/77, las que se han instalado en distintas zonas de las provincias citadas, y de acuerdo con las necesidades determinadas por la evolución de las densidades poblacionales regionales.

OBJETIVOS

Tiene por objetivo detectar los primeros nacimientos que se produzcan en una determinada zona infestada, vigilar la evolución de los mismos en el campo y asesorar a los productores agropecuarios sobre la oportunidad de realizar los tratamientos de control de la plaga.

REV. SOC. ENT. ARGENTINA, Tomo 36 (1-4): 55-57.

INSTRUCCIONES PARA LA INSTALACION DE LA ESTACION

a)—*Recolección de desoves:* Recolectar los desoves en los lugares donde se han observado en el último período alta densidad de población. Recoger la cantidad de diez desoves para cada una de las jaulas a instalar.

Los desoves recolectados se colocarán en bolsitas de polietileno, u otro material, conjuntamente con un rótulo en el cual se deberá indicar lugar y fecha de recolección y nombre del propietario del establecimiento, datos que luego se volcarán en una planilla que confeccionará la Estación. Los desoves deberán ser transferidos a las jaulas dentro de las 48 horas.

b)—*Instalación de la Estación:* Se instalarán tantas jaulas de acuerdo con la cantidad de establecimientos y/o áreas que se desee tener en observación, correspondiendo, en consecuencia, una jaula para cada lugar.

Se instalarán a campo descubierto, alejadas de cualquier factor (edificios, árboles, etc.) que pueda modificar las condiciones naturales del sitio donde fueron recolectados los desoves. Las jaulas se colocarán separadas 2 metros entre sí y entre fila. La puerta móvil de vidrio se orientará hacia el sur. El conjunto deberá estar cercado para protegerlo con seguridad de los animales.

Los desoves contenidos en las bolsitas se depositarán en número de diez, dentro de cada jaula, distribuidos uniformemente y cubriéndolos con una capa de tierra desmenuzada de 1 a 2 centímetros de espesor. El piso de la jaula deberá estar desprovisto de toda vegetación, o mantenerse la misma a la altura mínima posible, a los efectos de facilitar la verificación de la presencia de ninfas.

Características de la jaula: Cubo de 30 cms. por lado; patas de 8 cms. de largo; varilla de 3

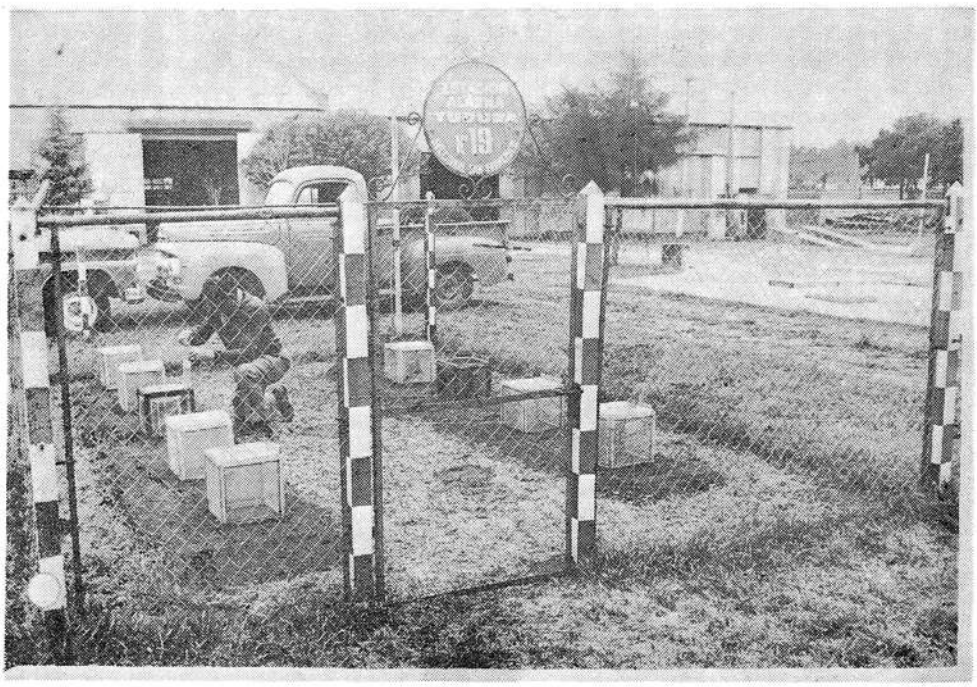

Fig 1. Detalle de instalación de una estación de alarma.

cms. sección cuadrada; puerta de vidrio; las 3 caras laterales y superior de tejido metálico y base libre.

c)—*Observaciones luego de la instalación:* Se realizarán diariamente a partir de la instalación de la Estación, a fin de registrar los nacimientos que se vayan produciendo en cada jaula.

d)—*Funcionamiento del sistema:* Se determinará el número mínimo de eclosiones de cada una de las jaulas para producir la información; teniendo en cuenta que se estableció la cantidad de 10 desoves por jaula (cifra que potencialmente representa un número aproximado de 200 tucuras), debe considerarse que al nacer el 20 o/o (40 tucuras), es el momento de poner en marcha el sistema de alarma de la siguiente manera: Comunicar la información sobre los nacimientos al Servicio Nacional y/o Provincial de Sanidad Vegetal correspondiente. Comunicar a toda la zona de influencia de la Estación por los medios de información de la prensa oral, escrita, radio, T.V., etc.

e)—*Iniciación de las actividades en el área:* Período de observación a campo: una vez comunicada la alarma, los productores deberán observar durante 30 días el comportamiento de la plaga en el campo. Los tratamientos de control deberán dar comienzo 15 días después de finalizar las observaciones mencionadas.

Se aconseja utilizar la información de la Estación para realizar el control prematuro del acridio, es decir, destruir los focos incipientes de ninfas, a fin de evitar la dispersión de los ejemplares y mayores daños en la vegetación.

RESUMEN
REMODELACIONES CROMOSOMICAS Y VALOR DEL NF EN ACRIDIDOS SUDAMERICANOS

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Facultad de Matemáticas y Ciencias Naturales, Valparaíso, Chile

La citotaxonomía ha dado a conocer el cariotipo de una gran cantidad de especies, lo que ha permitido postular que el número diploide (2n) es generalmente constante para una categoría determinada (Género Especie). Sin embargo, a pesar de esta estabilidad encontramos variaciones en el cariotipo de muchos de ellos.

"Un cierto tipo de remodelación sería una característica de un taxón dado White". (57).

El número cromosómico considerado ancestral en los Acrídidos es de 2n=23 en los machos y 24 en las hembras, a pesar de ser este grupo bastante estable, desde este punto de vista, se han detectado una serie de cambios en el 2n, llegando al caso extremo de *Dichroplus silveiraguidoi* 2n = 8. Es de hacer notar que estas remodelaciones son más frecuentes en el sistema cromosómico sexual, que de un sistema XO, varía a sistemas Neo X - Neo Y, X1 X2 Y, se ha descrito para especies del género *Dichroplus, Scyllina, Leiotettix*, etc.

Se discute en el rabajo los mecanismos que con mayor frecuencia están implícitos en estos cambios en los Acrídidos, especialmente sudamericanos.

Si entendemos que las remodelaciones cromosómicas son una de las bases del proceso evolutivo, resulta de gran valor conocer cuales son los mecanismos que permiten tales cambios.

El "NF" o número fundamental, toma gran importancia de analizar y tener presente sobre todo cuando ocurren estas remodelaciones. Muchos citogenetistas han tratado de relacionar el 2n con el NF y el grado evolutivo de una especie, pero es difícil darle un "valor filogenético" dado que especies de un mismo género presentan muy diferentes NF como por ejemplo en *Dichroplus* =2n = 23 NF = 23. *D. elongatus* 2n = 8 NF = 13 *D. silveiraguidoi*, pero para análisis citológicos es un dato de gran valor, el esclarecimiento de los mecanismos implícitos en las remodelaciones.

Se analiza además, la detección de bandas C y G, como factores marcadores en las remodelaciones.

GRASSHOPPER FEEDING BEHAVIOR AND THE DEVELOPMENT OF EDIBLE CARRIERS FOR GRASSHOPPER CONTROL AGENTS (1)

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INTRODUCTION

Our research on the isolation and identification of behavioral components of grasshopper host plant selection has shown the potential for utilizing behavior in applied programs for the evaluation and management of grasshopper populations.

The term "grasshopper" should be interpreted as a few species common to the grasslands of North Dakota. Species are mentioned in the tables.

Grasshoppers are a natural and important constituent of grassland ecosystem. Most species are benficial and management of populations would include positive as well as negative aspects. However, there are times when, coincident with certain weather conditions and land usages, grasshopper populations are of a size and composition that they damage vegetation. There is a need to be able to recognize and evaluate grasshopper populations, weather conditions, and land usage in order to minimize damage to grasslands.

At present, there is neither a real prospect for managing weather or climate nor is it easy to make rapid changes in land use. Within the past 30 years it has been possible to make drastic reductions in grasshopper populations by the application of chemical control agents such as aldrin, dieldrin, or malathion. However, the effect of these compounds on non–target organisms has been of great concern and restrictions have been placed on their use. Still, it does not appear possible to maintain an adequate supply of high quality agricultural products without the use of some control agents.

The ideal of any insect control or pest management program always has been to have the maximum effect on the target organism and the minimum effect on all other organisms.

(1) *Published with the approval of the Director of the North Dakota Agricultural Experiment Station as Journal article Nº 736.*

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One approach to this ideal would be the development and utilization of extremely selective control agents which would affect only a particular species. Because of the high cost of developing and producing chemical control agents the emphasis is more likely to be on the development of chemicals effective against a broad spectrum of pests, rather than selected ones. The development of biological control agents such as those indicated by the outstanding work of Dr. John Henry offers possibilities for this approach, (Henry and Oma, 1974).

Another approach to this ideal would be to selectively direct the application of the control agent so that only the target organisms would be affected, despite employment of a broad spectrum control agent.

The advantages of selective application include:

1. Less control agent is needed since less is lost or misdirected during application.
2. Fewer non–target organisms are affected by the control agent.
3. Selective suppression is possible. One may not desire to eradicate a population but only reduce its impact on a desirable feature. Since grasshoppers are an integral part of the grasslands environment, their sudden and complete disappearance may have adverse side effects.

Obviously, combining the selectivity of the control agent with a selective application would give maximum benefit. Drumond et al (1975) developed a Performance Index based on the inverse relationship of Pest Control Efficiency to Cost of Control.

$$\text{Performance Index (PI)} = \frac{\text{Pest Control Efficiency}}{\text{Cost to Produce Control}}$$

Efficiency was the inverse relationship of Pest Control Efficiency to Amount of Pesticide used.

$$\text{Pest Control Efficiency (PCE)} = \frac{\text{Pest Reduction}}{\text{Amount of Pesticide Used}}$$

Modifying this equation to account for the effects on non–target or non–pest organisms weights it in favor of selective control.

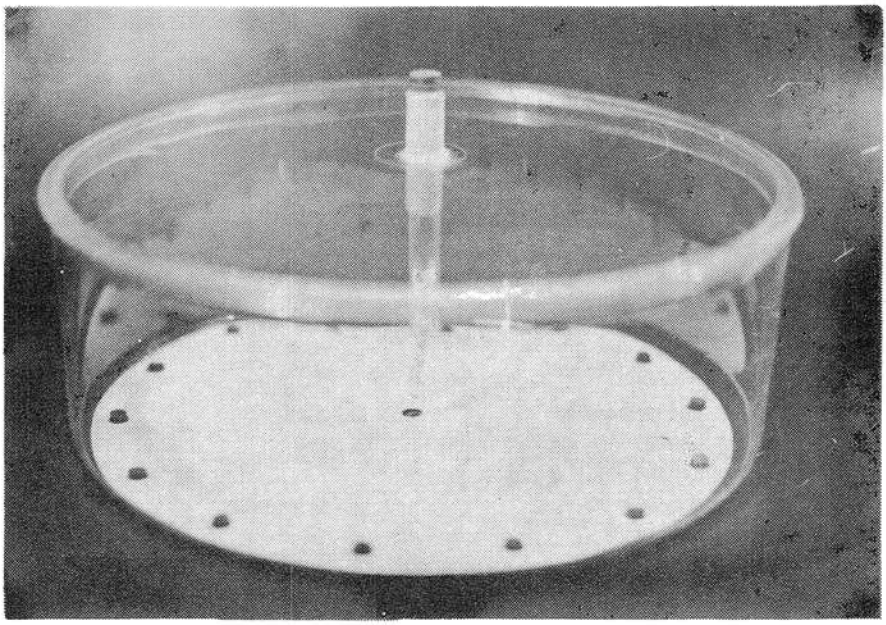
$$\text{PCE} = \frac{\text{Pest Reduction} - \text{Non–Pest Reduction}}{\text{Amount of Pesticide Used}}$$

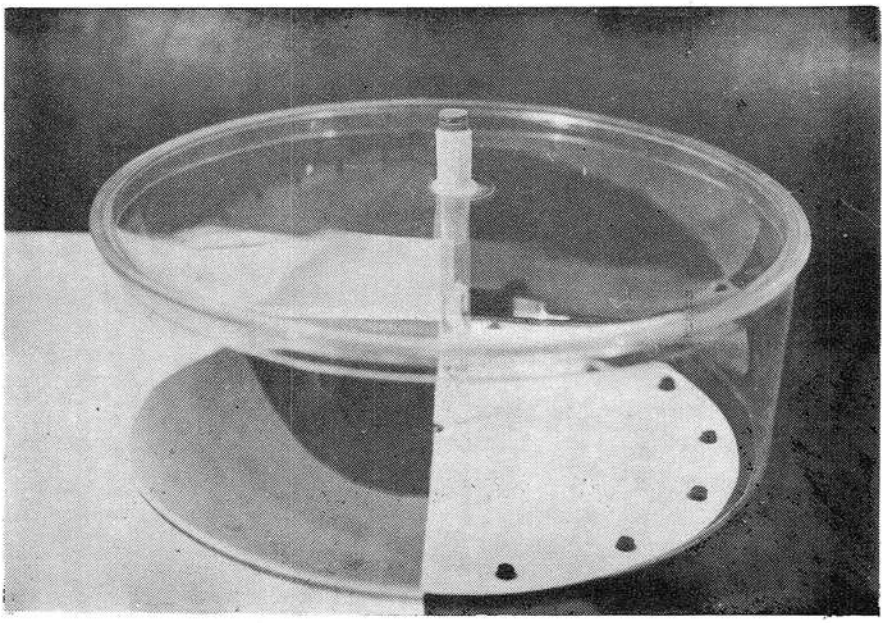
GRASSHOPPER BEHAVIOR

Before considering further the control aspect, we should describe some behavioral responses that were pertinent to the development of a control method. Our approach to this was mainly observational, utilizing intact insects in controlled laboratory and greenhouse conditions and in field situations with little or no attempt to alter existing conditions. Responses to stimuli were determined by direct observations of grasshoppers, often with time-lapse cinematography and indirectly by the ingestion of edible preparations as indications of activity in response to stimuli. ^{32}P was used to label preparations with the detection of radioactivity as an indication of feeding responses.

Grasshoppers are diurnal and more active under illumination than in the dark. They exhibit a positive photo-orthokinesis, and make undirected movements that keep them in illumination and out of darkened areas. They also show positive photoklinokinesis (Mulkern, 1967, 1969).

An experiment related food consumption to illumination in small plastic arenas 21 cm. x 8 cm. high (Figs. 1-3). Fourteen equal food tablets were arrayed around the





Figures 1-2. Plastic arenas with paper discs and outer cover used in feeding behavior experiments.

perimeter of a paper disc inserted on the bottom of the arena. The disc was all white, all black, or 1/2 black and 1/2 white. A black paper cover could be fitted to shield 1/2 of the arena from direct light. Since one effect of shading was to darken the background upon which the food was displayed, having the disc black could mimic this. With an all white or all black disc there was no detectable pattern of selection among the tablets (Fig. 4). With a black and white disc only 1 of 4 replicates had a significant difference in ingestion as determined by a t-test although there was a tendency for greater feeding on tablets in the white portion. Covering 1/2 of the arena which had a white disc resulted in significantly less feeding in the shaded portion. Covering the black 1/2 of a black and white disc also resulted in significantly less feeding in the shaded portion. Covering the white half of the disc resulted in greater ingestion in the black unshaded part, but the difference in mean ingestion was not significant. In part this was because of the large amount of feeding that took place on the tablets on the white 1/2 near the juncture of the 2 halves. Since all of the food tablets were the same, feeding was influenced by the response to illumination.

In arenas with alternate black and white segments there was significantly greater feeding on the tablets displayed on the white segments. Possibly the greater contrast of the dark tablets on the white display than on the dark display was responsible.

Grasshoppers probably feed at night in the field. However, in several years of analyzing the crops contents of grasshopper we have found that the incidence of empty remains high several hours after sunrise until it is warm enough to stimulate activity. The crops of grasshoppers collected late in the day or after sunset are usually full. There is a feeding periodicity that is fairly regular under the usual daily sun regime.

Grasshoppers feed and drink in the absence of light in the laboratory. Under continuous bright or dim artificial light there is an irregular periodicity of feeding not related to a 24-hour period. Grasshoppers held in separate containers under the same regime may have different patterns of activity (Mongolkiti, 1973).

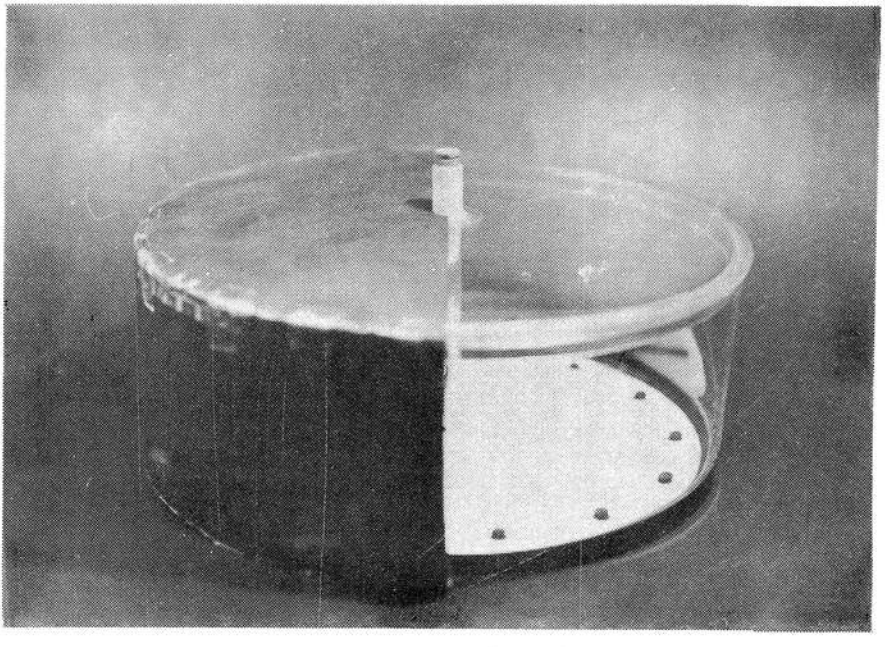


Figure 3. Plastic arenas with paper discs and outer cover used in feeding behavior experiments.

Grasshoppers were exposed to arrays of 4 tableted preparations, 2 with a phagostimulant and 2 without. Both preparations were palatable but the usual ratio of ingestion was 3:1 in favor of the phagostimulant. Six replicates were placed in a light-tight chamber and 6 were exposed to continuous light. The total feeding in the illuminated chambers was significantly greater (1.7:1) than in the dark ones but the ratio of feeding was about the same in each set, 5.6:1 in favor of the phagostimulant. Covering the compound eyes with an opaque paint did not cause a detectable decrease in total ingestion compared to unaltered grasshoppers but the ratio of feeding dropped to about 1:1. It would appear that general activity may be moderated by other receptors, and blinding the compound eyes decreases the searching activated by visual stimuli so a random feeding pattern occur. There is also a social stimulus, one feeding grasshopper stimulating others to feed. The mean food consumption of grasshoppers in groups of 3-5 is greater than that for grasshoppers held individually in the same conditions.

Grasshoppers respond to directed or point sources of light by orienting to and moving towards the light (positive photo-tropotaxis). With one eye covered they display the typical "circus movements" when illuminated from above. With intact grasshoppers, if more than one source of light is displayed and the intensity varied, response is always to the greater intensity. They discriminate differences in intensity of 2 lux, as fine as we could determine with available equipment. The heat or thermal radiation was equalized by water-filled containers as heat filters.

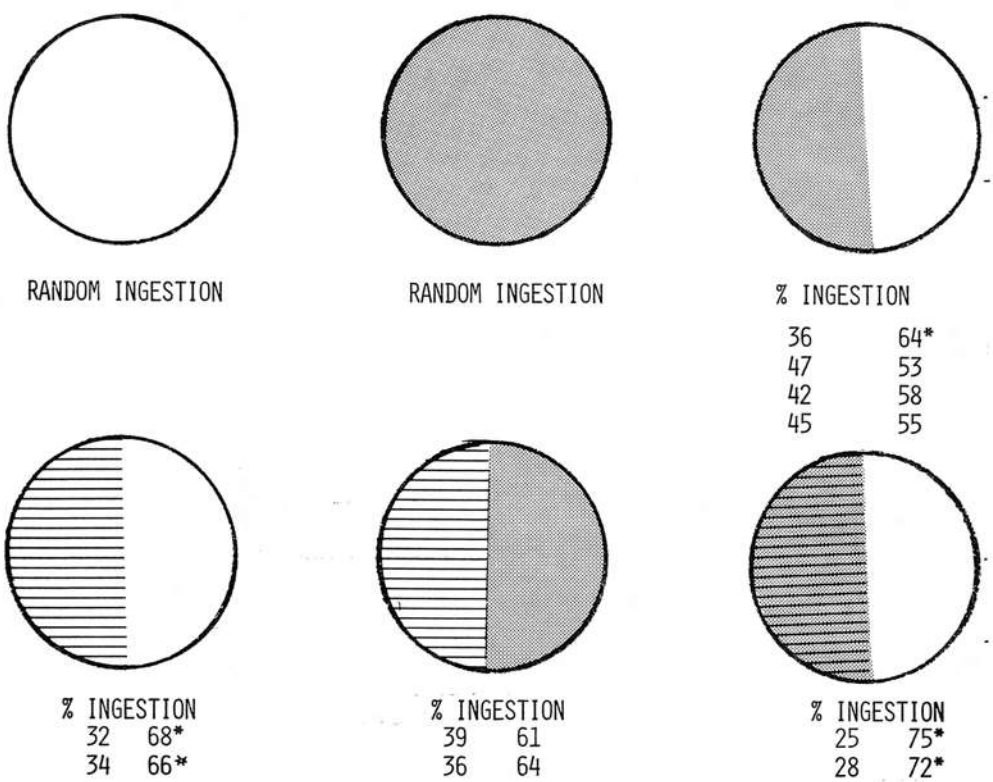


Figure 4. Percent ingestion of tablets displayed on different backgrounds. Stiple area is black, horizontal lines represent outer cover. *Indicates significant difference (P .05) by t-test).

The response to heat and light are separate. Grasshoppers align themselves for maximum or minimum exposure to the sun. They move to the shaded or sunlit side of an object in relation to the ambient temperature and the amount of radiation.

In the laboratory, 500 watt photoflood lamps which produced 2 x 10^5 lux and 1.2 c/cm^2 at 28 cm. from the source were directed at one end of a 1 m. long chamber. With water filled heat filters interposed, the grasshoppers were attracted towards the light. When the heat filter was removed, the grasshoppers retreated rapidly and moved to the shaded side of objects in the chamber. The grasshoppers could be induced to move back and forth across the chamber by moving the filter in and out.

Grasshoppers are negatively geo-tactic. The usual tendency is to crawl up objects and align their head upwards, even in the dark. They readily reorient if the surface upon which they are resting is realigned. However, if they are illuminated from underneath, they move downwards towards the source of illumination. Switching the light off and on or interposing appropriate filters causes the grasshoppers to reorient over and over again.

Thus, a grasshopper crawling up a plant to bask in the sun is responding to 3 different stimuli, in this case reinforcing each other, but in other circumstances over-riding each other.

Grasshoppers are most sensitive to or respond to radiations of light from 360 to 550 nm. That is, they moved toward or increased their activity when exposed to these wavelengths. There is less to little response from 600 to 1000 nm. or at 240 nm., the only wavelength below 360 tested. For example, a two-chamber reaction device (Fig. 5) allowed grasshoppers to respond to 2 simultaneous sources and filters. The complex transmission patterns of the filters (Figs. 6-8) make it difficult to identify exact wavelengths but the response is most pronounced in the lower range (Table 1).

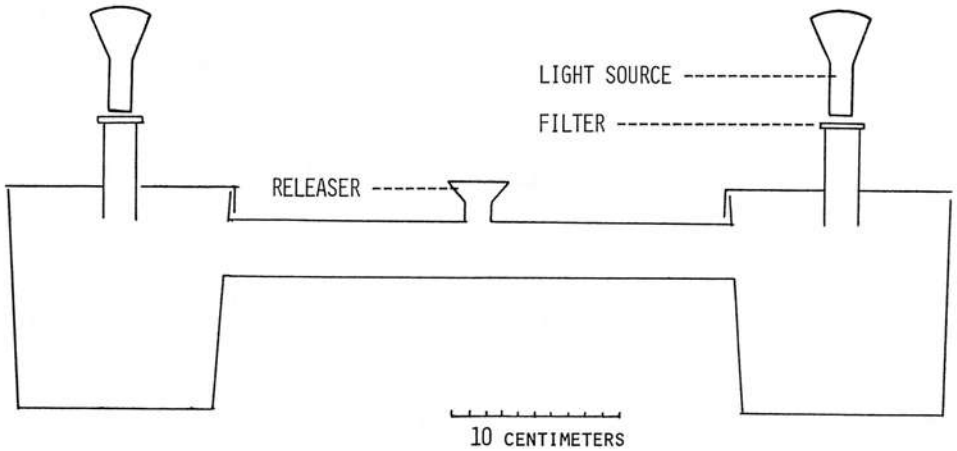
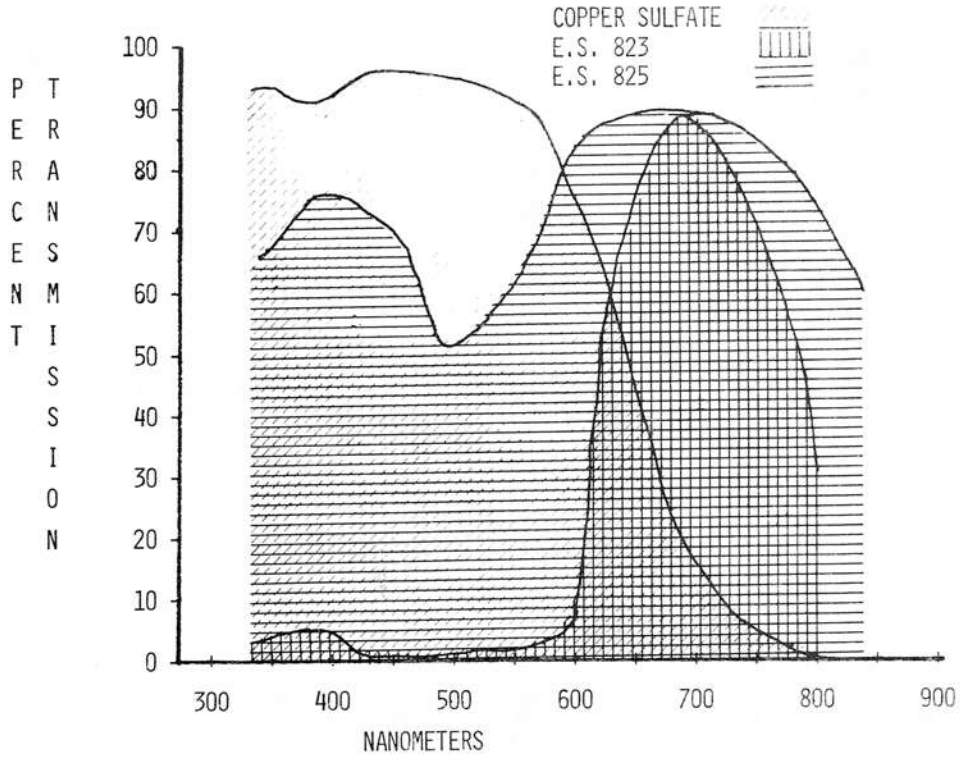
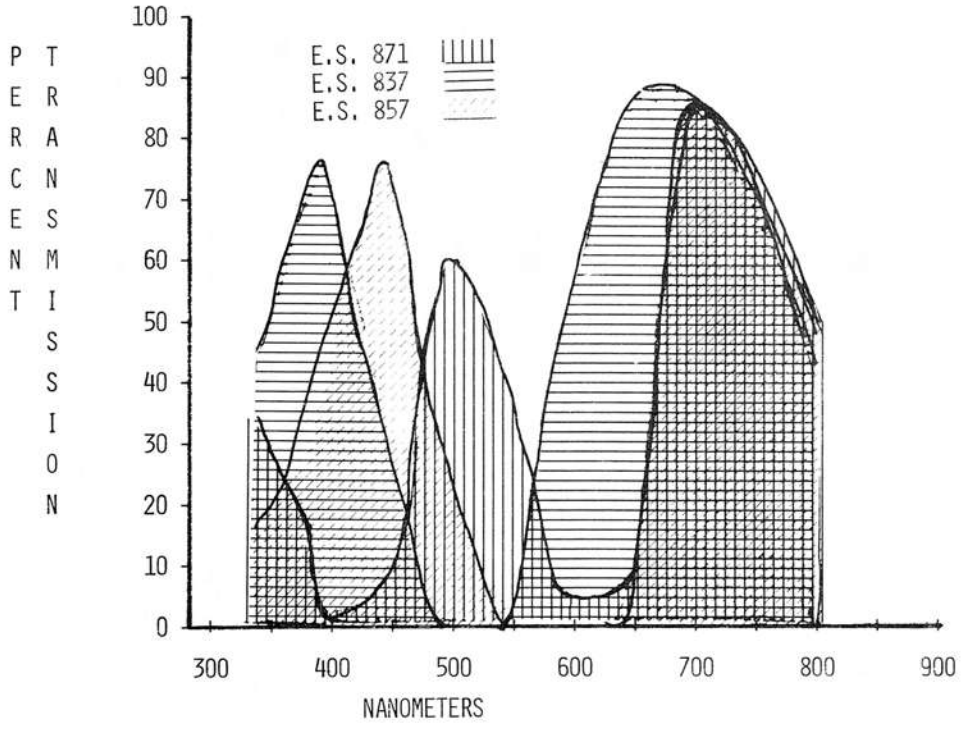


Figure 5. Two-chamber reaction device. Entire apparatus made of clear plastic covered with aluminium foil. Grasshoppers were released through center and travelled to chamber at either end.





Figures 6-7. Transmission curves of filters used in 2-chamber reaction device. Area beneath curves is filled in to emphasize overlap.

In view of the foregoing it is interesting that the reponse to artificial light under field conditions is quite limited.

Since grasshoppers are responsive to the range of wavelengths that includes the greens, colors associated with plants, there is a possiblity that color is a factor in host selection. Dyeing food materials, for example paper strips, always results in random selection with no influence by color (Table 2). Colored backgrounds upon which food material is displayed in laboratory or field experiments (Table 3) never indicates any influence by color.

Arrays of tablets were exposed in a chamber covered with black paper except for slits (2 x 7 cm.) on the top. The slits were covered with filters so that the tablets were each displayed in an area illuminated with a different wave length from 420 to 670 nm. There proved to be no significant differences in the amount of feeding among the colors.

Grasshoppers responded to visual patterns with the greatest positive response to contrasting vertical patterns. Any interface of contrasting patterns was effective, with the greater the linear interface, the greater the attraction. Narrow stripes down to about 3 mm. were more effective than equal areas of wide stripes with less linear interface (Mulkern, 1969). Grasshoppers ingested significantly more material arrayed on a vertical pattern than on a horizontal pattern in the greenhouse or in the field.

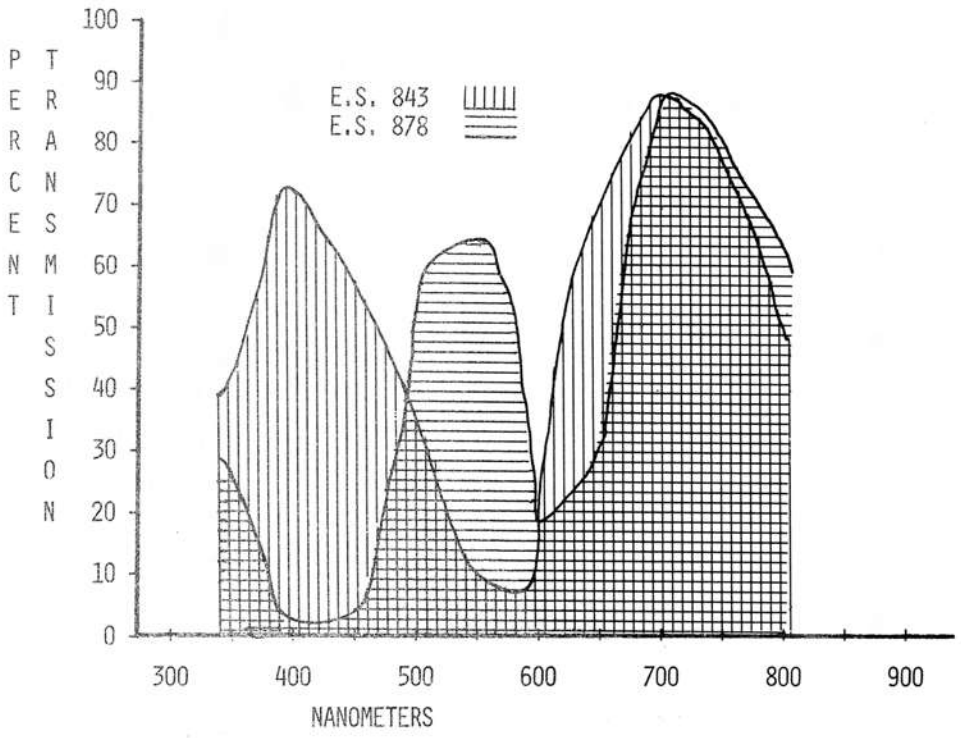


Figure 8. Transmission curves of filters used in 2-chamber reaction device. Area beneath curves is filled in to emphasize overlap.

TABLE1. Response of grasshoppers to filtered light[1] in 2 chamber apparatus

Filter	% Response n = 20 r = 10	
Pairs	*M. sanguinipes*	*M. confusus*
Copper sulfate	57*	30*
ES No 823	9	5
Copper sulfate	39	37
ES No 825	32	26
ES No 823	18	13
ES No 825	49*	38*
ES No 837	9	9
ES No 871	38*	39*
ES No 871	18	15
ES No 857	38*	37*
ES No 857	39*	37*
ES No 837	5	10
ES No 878	26	31
ES No 843	22	20

(1) Light source = Nicholas illuminators with intensities balanced.

* Significant difference (P = .05) between filters in pair. T−test.

TABLE 2. Ingestion of dyed paper (1) strips by 4 stadium *M. bivittatus.*

Color		Mean Ingestion in mg n = 10
Name	Methuen Notation	r = 8
Egyptian blue	21 C 7	8.3
Light turquoise	24 A 5	11.3
Copper green	26 B 6	10.1
Ocean green	27 C 7	7.3
Paris green	27 B 7	14.8
Apple green	29 C 7	7.9
Yellow	3 A 7	11.8
Brownish orange	6 C 6	9.0
Brown	8 E 5	3.7
Greyish ruby	11 D 6	4.4
Black	25 H 3	3.6
White	1 A 1	9.4

(1) Watman Nº 1 paper 1.3 x 5 cm. Schilling Food Colors in 1 M sucrose used to dye strips.

(2) Stakes were arrayed 30.5 cm apart around the perimeter of a 2.13 m diameter circle. Mainly adult and last instar. *M. femurrubrum* and *M. sanguinipes.* No significant differences among colors by analysis of variance (P = .05).

TABLE 3. Ingestion diet tablets(1) on stakes with colored panels exposed to field populations of grasshoppers(2).

Color		Mean Ingestion in mg
Name	Methuen Notation	n = 5
White	1′ A 1	39.6
Greyish green	30 C 4	34.7
Greenish grey	30 C 2	38.0
Greyish violet	15 C 4	27.8
Violet	15 D 5	46.9
Purple	15 C 6	50.3
Yellow	3 A 7	52.6
Bluish green	25 B 7	37.5
Green	26 D 7	31.9
Ocean green	27 C 5	47.3
Rose	11 A 6	51.3
Brownish violet	11 D 7	34.9
Dark red	10 C 7	56.3
Deep red	11 B 7	54.5
Reddish orange	7 B 8	44.0
Greyish turquoise	24 B 4	41.0
Porcelain (blue)	23 C 6	61.2
Greyish blue	20 D 5	39.8
Egyptian blue	21 C 7	44.6
Pastel pink	11 A 4	36.0
Brown	7 E 5	64.1
Black	25 H 3	61.5

(1) Basic diet carrier with. 25 g/g *Asclepias* extract + 2 %o chlorpyrifos.

(2) Stakes were arrayed 30.5 cm apart around the perimeter of a 2.13 m diameter circle. Mainly adult and last instar *M. femurrubrum* and *M. sanguinipes*.

No significant differences among colors by analysis of variance (P = .05).

DEVELOPMENT OF EDIBLE CARRIER

Plant extracts were bicassayed for nutritional and phagostimulatory agents by incorporating them into a basic diet carrier. This carrier was processed into trituration tablets to form a palatable material nutritionally adequate to sustain grasshoppers for several days (Mulkern and Toczek, 1970). The palatability and nutritional value were enhanced by the addition of plant extracts. Grasshoppers readily ingested these tableted preparations and could discriminate among different plant extracts and extract concentrations in the laboratory. The most active phagostimulant was the water extract of *Asclepias Syriaca.*

In competition with growing plants in laboratory and greenhouse tests, this preparation was found and ingested by grasshoppers. Since the diet preparation was to be tested as a carrier for control agents it was necessary to determine the effects of these on feeding behavior. Preparations with carbaryl, chlorpyrifos, or malathion caused no detectable differences in the initial feeding behavior of grasshoppers as compared to preparations without insecticides. However, within a few minutes after feeding, the grasshoppers ceased feeding and began to show symptoms of insecticide poisoning. Grasshoppers feeding on non-insecticide tablets continued feeding and ingested more material. In all experiments the grasshoppers eventually fed on the insecticide tablets and died.

There were no detectable differences in feeding among tablets with concentrations from .5 to 5 o/o carbaryl.

For example, ^{32}P- labelled tablets with and without 2 o/o carbaryl were tested in competition with growing vegetation in greenhouse cages. A single 50 mg. tablet was placed among an estimated 60-100 g. of barley and/or yellow sweet clover. The actual insecticide was 1 mg. (equal to 14 g/ha). Ten 4th stadium *M. bivittatus, M. differentialis,* or *M. femurrubrum* were introduced into the cages. Dead grasshoppers were collected each day and the radioactivity determined. Those alive at the end of 3 days were killed and the radioactivity determined. 40 to 70 o/o of the grasshoppers were radioactive, indicating that they had fed on the tablets (Table 4). During exposure, 80-100 o/o of the grasshoppers with carbaryl tablets died. Not all of the dead grasshoppers had significant radioactivity levels and may have died of causes other than carbaryl poisoning. Some died in the cages without cabaryl. For the tablets without carbaryl, dividing the weight loss by the number of grasshoppers with radioactivity more than twice background yielded an average ingestion of 1 to 3.4 mg. per grasshopper for 3 days. When exposed to the tablets alone, without vegetation, *M. differentialis* consumed an average of 16 mg. per day and *M. femurrubrum* 5.6 mg. per day. For the tablets with carbaryl, the ingestion per radioactive grasshopper was 130-200 micrograms for 2.6 to 4 micrograms of carbaryl per grasshopper in this confined environment.

Results from both laboratory and greenhouse tests indicated that the artificial diet preparations with *Asclepias* extract were readily ingested by grasshoppers. Thus, the next step was to determine if similar results could be obtained in the field with normal host plants. Initial tests were made in wood frame cages with saran screen covering. These could be folded for transport and were placed over various types of vegetation. In each cage artificial diet tablets with *Asclepias* extract and ^{32}P were placed on the ground or displayed on different types of stakes. The cages were stocked with grasshoppers and other insects swept from the surrounding area. All insects were removed and analyzed after 2 or 3 days.

Many grasshoppers, crickets, and tettigoniids ingested the materials as evidenced by radioactivity. Radioactive ants were found, otherwise no other insects were radioactive. Because wheat bran had been used as an edible carrier or bait for grasshopper control agents, ^{32}P-labelled bran flakes or tablets with bran in them were exposed in cages. Radioactive grasshoppers were found but the bran did not seem as effective as the diet material nor as easy to handle.

Tablets were then exposed in open plots with no barriers to grasshopper movements. The plots were each 25-square yards (20.9 m^2) situated in areas of dense or sparse vegetation of various composition. Three different rates (.75, 2.5 and 3.75 g.), 2 distribution patterns (dispersed or clumped), and 2 placements (on stakes or on the ground) were compared. For the dispersed method, 1, 2 or 3 tablets were glued to the top of flat wooden stakes. Twenty-five stakes were evenly placed 1/yd^2 in 5 x 5 row pattern. Tablets were glued singly to unpainted wood splints and laid on the ground at 1, 2, or 3 per square yard. The splints were used in accounting for the tablets as they were eaten.

TABLE 4. Counts/minute for ^{32}P for 10 grasshoppers exposed 3 days to ^{32}P-labelled tablets in greenhouse cages with growing vegetation.

	M. differentialis		*M. bivitattus*		*M. femurrubrum*	
	85*(1)	72	116*	315	2113	916
	68*	63	85*	109	675	657
	57	56*	50*	67	431	332
	53*	53	47*	64	286	352
	44*	26	42*	42*	184	128
	44*	21	41*	16	46	59
	37*	19	37*	15	43	28
	16*	15*	31*	14	14	15
	16*	11*	25*	10*	13	14
	8	8	19*	9	10	11
Plant	YSC	Barley	Barley	Barley	Barley	YSC
% Carbary in tablet	2	0	2	0	0	0

(1) Background level for all counts was 10 CPM. For control grasshoppers not fed on ^{32}P tablets, for all trials level was 13 CPM. Counts > 2X background considered evidence of radioactivity.

YSC = Yellow sweet clover. * = grasshopper dead before end of exposure.

For the clumped distribution 25, 50, or 75 tablets were glued to round wooden stakes placed in the center of a plot.

The stakes were covered with clear plastic caps to shield the tablets from rain and comply with safety procedures for handling ^{32}P.

The plots were sampled by erecting a portable saran screen 1.8 m. high that enclosed 9 square yards in the center (Mulkern *et al.* 1964). All insects within the enclosure were collected whith a vacuum sampling device. In addition, sweep nets were used to collect insects within 3 m of the outside perimeter of the plots. Pitfall traps were placed both within and outside the plots.

Plots were sampled after 2 or 7 days. The 7-days samples were of litle value as very few radioactive insects were recovered. The 2-days samples yielded many radioactive grasshoppers. In plots with the dispersed pattern, 20-26 o/o of the grasshoppers (30-70/plot) were radioactive. In the clumped patterns only 3-5 o/o of the grasshoppers were radioactive.

All of the tableted material was gone within 2 days in the dispersed pattern plots but most of the material in the clumped pattern plots was left at 7 days. Stakes with 50-75 tablets were left exposed for 28 days but there was litle evidence of feeding on the tablets. From analyses of timelapse films of stakes exposed in the field it appeared that grasshopers within 1-2 m. of the stakes readily moved towards and onto them but at greater distances there was little or no attraction.

The variation withing and among treatments precluded quantitative analyses but grasshoppers did readily find and feed upon the artificial diet material in presence of lush natural vegetation. Considering all of the plots, 25 of 28 species of grasshoppers, 3 species of crickets, and 4 of tettigoniids were radioactive (Table 5). Many ants were radioactive and ants were seen feeding on the tablets. Only 3 other insects, 2 sarcophagid flies and 1 reduviid adult, out of several hundred, were radioactive. The reduviid, a predator, may have fed on a radioactive grasshopper. Several radioactive spiders were collected. Six radioactive grasshoppers were found on spider webs, indicating that the spiders had fed on radioactive grasshoppers.

For field tests of control agents in edible carriers the tableted preparations with 2-5 o/o carbaryl or chlorphyrifos were attached to wood stakes or placed on the ground. In repeated tests in different habitats with increasing plot sizes from 300-3000 m^2 similar results were obtained. Large numbers of dead grasshoppers were observed in the vicinity of the insecticide preparations but sequential sampling revealed no significant differences in the populations 2 to 9 days after treatment. It was feid that the small size of the plots in relation to the surrounding area allowed for grasshopper movement into the plots.

The logistics of making and setting out large numbers of wooden stakes made enlarging the plot sizes increasingly more difficult. However, there seemed to be value in using the stakes as a visual stimulus to attract grasshoppers.

Black patterns were printed on both sides of white index stock paper which was then cut into strips. Each strip had 3 vertical white stripes on a black background. The

TABLE 5. Arthropods collected in plots whith ^{32}P–labelled tablets.

ORTHOPTERA
Acrididae
Gomphocerinae
*Aeropedellus clavatus**
*Ageneotettix deorum**
Amphitornus coloradus
Chloealtis conspersa
*Chorthippus curtipennis**
Eritettix simplex
*Orphulella speciosa**
*Pseudopomala brachyptera**
Oedipodinae
Pardalophora haldemanii
*Spharagemon collare**
Melanoplinae
*Hesperotettix viridis**
*Hypochlora alba**
*Melanoplus angustipennis**
*M. bivittatus**
*M. borealis**
*M. confusus**
*M. dawsoni**
M. femurrubrum
M. flavidus
*M. foedus**
*M. keeleri**
*M. sanguinipes**
Phoetaliotes nebrascensis
Cyrtacantharidinae
*Schistocerca lineata**
Tettigoniidae
*Conocephalus spp.**
*Neoconocephalus ensiger**
*Orchelimun spp.**
*Scudderiza pistillata**
Gryllidae
*Acheta assimilis**
*Allomobius fasciatus**
*Oecanthus nigricornis**

DIPTERA
Asilidae
Chironomidae
Culicidae
Muscidae
Sarcophagidae*
Syrphidae
Tabanidae
HOMOPTERA
Cercopidae
Cicadelliae
Fulgoridae
Membracidae
HEMIPTERA
Coreidae
Lygaeidae
Miridae
Nabidae
Pentatomidae
Reduviidae*
LEPIDOPTERA
Larvae and adults of both moths and butterflies
COLEOPTERA
Carabidae
Chrysomelidae
Cleridae
Curculionidae
Meloidae
Scarabaeidae
HYMENOPTERA
Formicidae*
Ichneumonidae
Vespidae
ARANEIDA
Many spiders, 6 with radioactive grasshoppers in web were radioactive

* Radioactive specimens captured.

bottom edge was folded diagonally twice to form a point and stapled (Fig. 9). The fold and staple weighted the end and curved the plane of the strip so that it would spiral-glide downward into the vegetation. Tablets were glued to the tops of stakes and they were distributed by hand-throwing in the plots. Results of tests in 3700 m^2 plots were similar to those obtained before. Up to this time tablets were prepared in a small trituration mold which limited production. A faster method was developed. A large mold made 31.5 g. slabs of the diet preparation which could be cut into 50 mg. tablets with a rotary slicer.

Carbaryl at at rate of 8 g. per hectare was applied to 8000 m^2 plots in the form of the basic diet carrier (2 o/o carbaryl) or a pelleted a apple pomace bait with 5 o/o carbaryl (Union Carbide Sevin Baits^R). The diet carrier was distributed as tablets attached to paper stakes or scattered loose on the ground and as uncut slabs. Control plots with no treatment, with paper stakes only, or with the basic diet tablets without insecticide attached to stakes or the ground were used for comparison.

The materials were evenly distributed, 1 stake for 3.3 m^2, 1 tablet for 8 m^2, 1 pellet for 2.7 m^2 and 1 slab for 500 m^2.

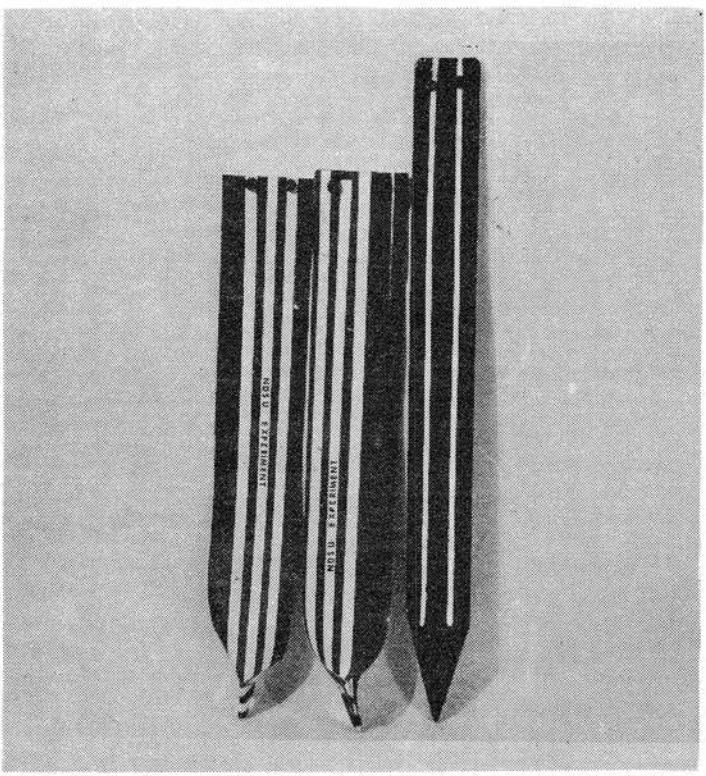


Figure 9. Paper (left) and wood (right) stakos used to display tablets in field experiments.

All plots were sampled weekly with a cage vacuum sampling device (Fig. 10) starting 2 weeks before treatment and continuing 5 weeks after treatment.

The results were inconclusive but interesting. The number of grasshoppers in all plots declined over the 9 days after treatment, although in most plots the differences were within the limits of sampling error (Table 6). The greatest differences were in the plots treated whith 2 o/o carbaryl-basic carrier with or without stakes, 2 to 5 times the decline in the other plots. The mean decrease in the non-insecticide plots was 5.4 grasshoppers per square meter. The mean decrease in the 2 plots with 2o/o carbamyl tablets was 21.8 grasshopper/m^2, a difference of 16.4 grasshoppers per square meter. The actual amount of insecticide was 1.2 mg. per square meter or 0.75 micrograms per grasshopper decrease. The plots with 2 o/o carbaryl slabs or 5 o/o apple pomace bait were no different from the non-insecticide plots.

The tablets on the stakes were gone within 9 days after application. As long as tablets were present grasshoppers could be seen feeding on them and freshly killed or dying grasshoppers collected. In some samples there were more dead grasshoppers per square meter than the original estimate of live grasshoppers. There were dead grasshoppers in the inmediate vicinity of the uncut slabs but no noticeable reduction in numbers. Approximately 60 o/o of the slab material remained 35 days after application.

The plot treated with 2 o/o carbaryl tablets on stakes was retreated with the same dosage 28 days after the first treatment, 19 days after the disappearance of the tablets from the first treatment. The mean number of grasshoppers was then 4.6 m^2 and it was reduced to 0.4/m^2 within 2 days. No further reduction in numbers was observed although some tablets remained for 35 days. It was difficult to sample low populations as the sampling error was large in comparison to the sample size. It also appeared that there was an irreducible minimum population that persisted despite treatment.

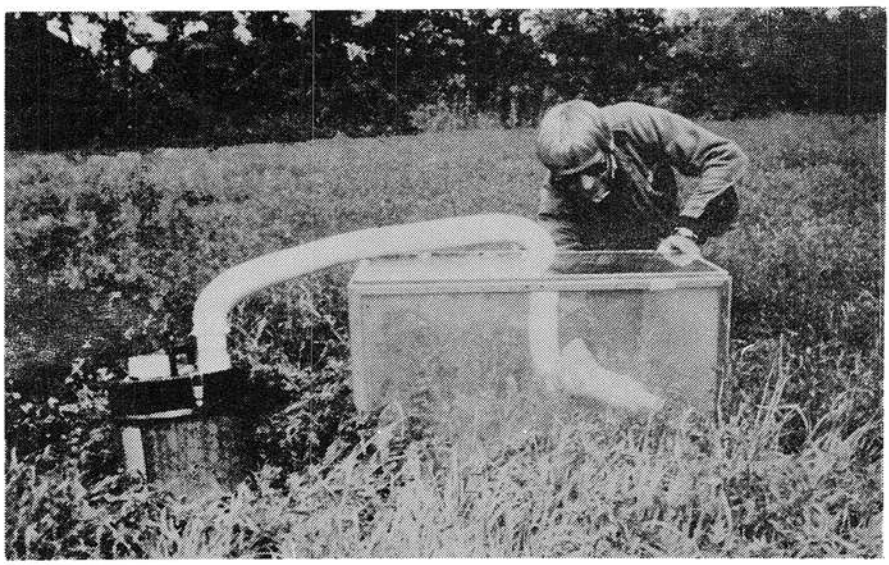


Figure 10. Cage-vacuum sampling device. Grasshoppers are collected into small plastic bags inside vacuum chamber at left.

Several experiments demonstrated that the effective range of the attractant preparations was less than 3 m, no matter what quantity of material was present. Even distribution of 30 to 80 mg. aliquots gave effective population suppression while the same quantity in 30–34 g. aliquots gave none.

The principle of sele tive suppression appeared to be effective and the method needed testing on large areas.

Previous experiments had shown that grasshoppers would feed on various papers if suitable phagostimulants were present. After testing many types it was determined that the consistency, stiffness, thinness, texture, etc., of newsprint paper was suitable for grasshoppers feeding. The paper itself was not ingested to any extent but the paper absorbed solutions with pphagostimulants and dried to a suitable texture. Newsprint was readily available in the form of discarded newspapers.

TABLE 6. Change in grasshopper numbers after treatment with edible carriers.

	Grasshoppers/m^2					
	Days after Treatment			%	Actual Decrease	
Treatment	0	2	9	Reduction(1)	%	Mean Grasshoppers/m^2
None	16.8^a	20.4^a	12.0^a	—	−29	4.8
Tablets	15.5^a	11.8^{ab}	9.0^b	19	−42	6.5
Stakes	8.1^a	5.0^a	5.9^a	0	−27	2.2
Tablets + Stakes	20.7^a	14.3^a	12.6^a	15	−39	8.1
Tablets + 2% Carbaryl	25.3^a	11.8^{ab}	4.5^b	75	−82	20.8
Tablets + Stakes + 2% Carbaryl	27.3^a	9.8^b	4.5^b	77	−84	22.8
Slabs + 2% Carbaryl	9.2^a	12.9^a	7.6^a	9	−17	1.6
Apple Pomace + 5% Carbaryl	11.8^a	12.3^a	6.7^b	21	−43	5.1

(1)Calculated by Abbott's formula. Means in rows with different superscript differ significantly (P = .05) determined by Duncan's Multiple Range Test. Actual insecticide rate was 8 g/ha.

The presence of insecticides did not alter the initial feeding response but did limit the amount of feeding as grasshoppers were affected by the insecticide.

Based on measurements of feeding and dissections of killed grasshoppers, about 2–4 mg. of treated paper (.25–.5 $cm.^2$) with 37–74 micrograms carbaryl, was the actual consumption for a medium-sized grasshopper like *M. sanguinipes*.

The most effective way to distribute the paper in the field was to shred it into strips which were in themselves attractant visual patterns for the grasshoppers.

In small plots treated with paper strips at 90 g/ha carbaryl, there was a reduction of 86 o/o in a population of 20 grasshoppers per square meter. The reduction occurred within 2 days. No further reduction was observed although paper strips were still present 60 days after distribution. No feeding on the strips was observed after 5 days exposure. In other experiments the palatability of the paper decreased after a few days of outdoor exposure.

The paper could be stored for months in sealed plastic bags at -18° or several weeks at room temperatures with no loss of palatability.

It appeared that exposure to sunlight was the principal cause for loss of palatability. This was in contrast to the diet preparations which retained paltability after several weeks exposure to sunlight. Rainfall sufficient to soak the paper also reduced palatability.

For field tests, the carrier was produced by soaking 20 cm. squares of salvaged newsprint (old newspapers) in a solution of *Asclepias* extract and sucrose with carbaryl suspended in it. The squares were pressed in a wringer to remove excess liquid and either freeze-dried or warm air-dried or a combination of both. The dried carrier contained 5 o/o carbaryl by weight.

A truck mounted shredder-blower (Fig. 11) was developed to distribute large quantities of the newsprint carrier. A paper shredder was mounted over a chamber with

Figure 11. Truck mounted shredder-blower for distributing paper edible carrier. Paper blown through duct at left.

an air duct extending from the chamber. A flexible hose connected the chamber to a gasoline or electric powered blower. The shredded paper fell into the chamber and was carried out the air duct "barrel" on the air stream provided by the blower. One 20 cm. square produced 45 strips about 4.5 mm. wide which were evenly distributed over a 2.5x4 m. area (about 4 strips/m^2). It was calculated that at 8.5 Kph, an even distribution of strips could be made at 4.5 ha/hr. This expectation was not reached.

Three sets of 2–ha plots were set out in grassland habitats. One plot in each set was treated with the edible carrier and 1 left untreated for comparison. The grasshopper populations were determined with a cage-vacuum sampling device prior to treating and 2 and 7 days after application. The number of paper strips/m^2 was also determined.

The grasshopper population varied among the 3 test sites (Table 7) with 28 species represented. Only 8 species were numerous.

The gasoline-powered blower was unreliable under actual operating conditions and because of difficulties with the blower, the strips were not distributed as evenly as expected and the actual dosages of insecticide altered. Instead of 2 hectare plots 123.5 g/ha, the rates ranged from 130 to 217 g/ha. and the plots from 1.1 to 1.9 ha.

There were significant reductions in the mean number of grasshoppers per square meter in the treated plots aat 2 and 7 days after application (Table 8). Using Abbott's formula the reduction ranged from 57-80 o/o but the sample variation influenced this as the formula is based on the change in populations in the treated and untreated plots. The differences in sample means in untreated plots were not significant.

Reduction calculated directly ranged from 68-74 o/o. The actual decrease was 6.4-16.8 grasshoppers per square meter.

All 8 numerous species were similarly reduced by the treatment. All species appeared to be affected by the treatment.

Because of the difficulties with the distribution of the shredded paper several modifications of the system were made. Newsprint end-rolls were obtained and cut to 20 cm. widths. The paper was processed into continuous rolls which could be fed into the shredder. Molasses was substituted for the plant extracts as a phagostimulant. The blower system was modified so that the shredded paper fell into the airstream of a large fan mounted on the back of a truck (Fig. 12).

Plot sizes were increased to 4 ha. The populations varied among the test sites (Table 9) with 32 species represented. Only 11 were numerous.

There were significant reductions ($P = .05$) in the mean number of grasshoppers in the treated plots at 2 and 7 days after application (Table 8).

Plots K and L received 2.6 cm. of rain on the 4th day after application. This did not seem to have any effect on population reduction as most of the deaths had occurred by then. The smaller decrease in plot L is the result of blower malfunction that caused uneven distribution of the paper leaving significant areas untreated. An analysis of the frequency of sample numbers indicated the mean was influenced by the variance resulting from large samples being picked up in the untreated portions rather than a general failure to reduce the populations. Plot I received 1 cm. of rain 12 hours after treatment. There was a noticeable decrease in the palatability of the strips as little feeding or mortality occurred after the first day. Most of the decrease resulted from the few hours of feeding before the rain. Some of the reduction in control plot H may have resulted from movements of grasshoppers into the treated plots.

The actual grams of insecticide (Table 10) per mean grasshopper decrease ranged from 0.77 to 2.7 x 10^{-3}. The mean of all plots was 1.46 x 10^{-3} compared to a calculated 8.56-12.85 x 10^{-3} assuming 99,o/o control at the recom mended rate of 1.2 to 1.68 kg/ha.

TABLE 7. Species composition of grasshopper population in 1975 test plots.

Species	Percent of Total(1) Richland A	Slope C	Slope E
Aeropedellus clavatus	+		
Ageneotettix deorum	+	11	+
Amphitornus coloradus	+	+	+
Chloealtis conspersa			+
Chorthippus curtipennis	+	+	+
Eritettix simplex	+	+	+
Opeia obscura	6	22	+
Orphulella speciosa	9	+	+
Phlibostroma quadrimaculatum		6	
Pseudopomala brachyptera			+
Arphia conspersa	+	+	
A. pseudonietana	+	+	+
Encoptolophus sordidus		+	
Pardalophora haldemanii	+		
Spharagemon collare	+		+
Trachyrhachys kiowa		7	+
Hesperotettix viridis	+		+
Melanoplus angustipennis	+		
M. bivittatus	+		+
M. confusus	+		
M. dawsoni	+		+
M. femurrubrum	+	+	+
M. flavidus	+		
M. foedus (2)	+	+	+
M. infantilis		11	+
M. keeleri	+		+
M. sanguinipes	65	11	44
Phoetaliotes nebrascensis	+	21	46

(1) + = present, less than 5o/o, no figure means species not present.
(2) may include *M. packardii.*

TABLE 8. Mean grasshopper numbers in plots treated with 5% carbaryl in edible carrier newsprint strips.

Plots	Hectares Treated	Carbaryl g/ha	Grasshoppers/m^2 *Days after treatment*(2) 0	2	7	% Reduction(1)	*Actual decrease* %	m^2	Location	Date Treated
A	1.45	173.0	9.31^a	2.45^b	2.87^b	72	69	6.4	Richland Co.	30 July 1975
B		0	6.09^a	5.81^a	6.79^a		0	0		
C	1.93	130.0	22.47^a	8.89^b	5.67^b	80	75	16.8	Slope Co.	12 August 1975
D		0	13.09^a	11.97^a	17.71^a		0	0		
E	1.15	217.4	14.19^a	7.28^b	4.57^b	57	68	9.6	Slope Co.	12 August 1975
F		0	10.50^a	13.62^a	8.02^a		24	2.5		
G	4.05	123.5	12.23^a	1.77^b	0.89^b	89	93	11.3	Richland Co.	6 July 1976
H		0	8.07^a	8.49^a	5.51^b	32	32	2.6		
I	4.05	123.5	12.60^a	3.31^b	2.47^b	65	80	10.1	Richland Co.	13 July 1976
J		0	9.80^a	7.42^a	11.01^a		0	0		
K	4.05	123.5	14.00^a	1.73^b	0.93^b	90	93	13.1	Slope Co.	28 June 1976
L	4.05	123.5	13.35^a	4.01^b	3.64^b	68	73	9.7		
M		0	16.25^a	11.15^a	13.44^a		17	2.8		

(1) Calculated from Abbott's formula.
(2) Means in any row not superscripted by same letter differ significantly (P= .05) determined by Duncan's Multiple Range

TABLE 9 Species composition of grasshopper populations in 1976 test plots.

Species	*Percent of Total*[1]			
	Richland		*Slope*	
	G	I	K	L
Aeropedellus clavatus	+	+	+	+
Ageneotettix deorum	21	5	30	16
Amphitornus coloradus	49	6		
Chorthippus curtipennis	+	+		
Eritettix simplex	+	+		
Mermeria maculipennis				+
Opeia obscura	+	19		+
Orphulella speciosa	+	8		+
Philoboetroma quadrimaculatum			+	13
Psoloessa delicatula				+
Arphia conspersa			+	+
A. pseudonietana	+	8	+	+
Encoptolophus sordidus	+			+
Hadrotettix trifasciatus			+	+
Metator pardalinus			+	
Pardalophora haldemanii	+			
Spharagemon equale			6	+
Trachyrachis kiowa		+	+	10
Hypochlora alba			+	5
Hesperotettix viridis	+			
Melanoplus angustipennis	+	+		
M. bivittatus		+	+	+
M. bowditchi				+
M. confusus	+	+		
M. femurrubrum		+		+
M. flavidus		+		
M. foedus[1]	+	+	+	+
M. infantilis			31	21
M. keeleri	+	+		
M. sanguinipes	21	43	15	10
Phoetaliotes nebrascensis	+	+	+	9
Schistocerca lineata	+			

(1) + = p resent, less than 5%, no figure means species not present.
(2) Mav include *M. packardii.*

TABLE 10. Mean decrease in grasshopper numbers in treated plots.

	Plot	Decrease Grasshoppers/m^2	Carbaryl g X 10^{-3} Per Grasshopper Decrease
1975	A	6.4	2.70
	E	9.6	2.26
	C	16.8	0.77
1976	L	9.7	1.27
	I	10.1	1.22
	G	11.3	1.09
	K	13.1	0.94

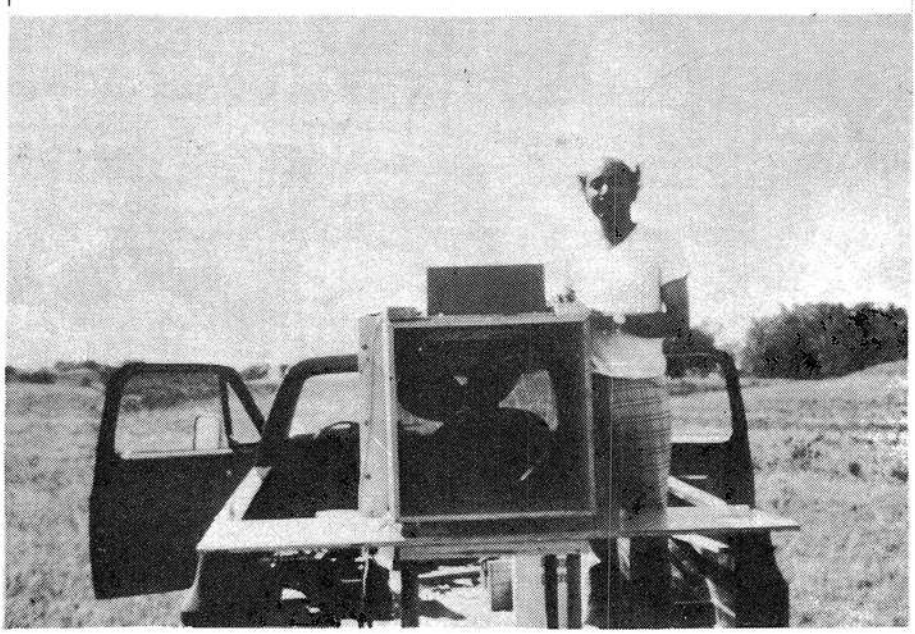


Figure 12. Truck mounted shredder-blower for distributing paper edible carrier. Paper blown out by fan.

The cost for materials was:

	Per Acre	Per Hectare
Paper	.197	.486
Molasses	.237	.585
Carbaryl	.338	.835
TOTAL	$0.772	$1.906

Because less than one-half of the paper was consumed the amount of carbaryl can likely be reduced. Further tests will be made for this.

Other than grasshoppers, the only insects observed feeding directly on the paper strips were crickets, tettigoniids, and ants. Predators and scavengers, including crickets, tettigoniids, and ants, as well as carabids, cicindelids, reduviids, etc., were indirectly affected by eating dead or dying grasshoppers. Grasshoppers themselves fed on dead or dying comrades and recycled the insecticide.

Other insects such as bees, flies, lepidopterans, hemipterans, etc., were not affected by the application of insecticide in the edible carrier.

Returning to the Performance Index, some speculations may be made. Granting 99 o/o control to carbaryl at 1.12 kg/ha. gives a PCE of .88. This would be lowered if the non-target population reduction were considered. The Performance Index calculates to 0.116.

Granting 90 o/o control to the edible carrier, the PCE becomes 7.29. The reduction for non-target effects would be lower than for broadcast application. The Performance Index becomes 3.82.

The cost of production of the edible carrier is not included. It is difficult to calculate. The cost of application is also not included. These may lower the PI of the edible carrier but the carrier still appears promising, especially because of the selectivity of control.

Each treated paper strip is equally effective in killing grasshoppers that feed on it. However, the total number of grasshopper killed in a large area is directly related to the density and distribution of the paper strips. The dosage rate and the number of grasshoppers killed per m^2 can be determined by controlling the density and distribution of the paper strips. Thus, selective suppression, including limited or controlled reduction in population densities, can be obtained. This differs from broadcast applications where dosages lower than recommended rates often result in disproportionately lowered effectiveness; that, is the rate of control drops of rapidly as the amount of insecticide is decreased.

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ABSTRACT

TAXONOMIC STATUS OF THE GENUS *MELANOPLUS*, WITH SPECIAL REFERENCE TO THE *MONTANUS* SPECIES–GROUP

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The genus *Melanoplus* is one of the most important grasshopper genera in North America because it now includes about 200 described species, several of which are serious crop pests, and many others are prevalent on rangeland. A wide variety of brachypterous and fully winged species occur in the United States. Rarely is a brachypterous species represented also by long-winged individuals except with a few species such as *Melanoplus dawsoni*. During the early pioneer period of American insect systematics many of the brachypterous species were placed in the genus *Pezotettix*, now restricted to the Old World. Long-winged species were frequently placed in *Caloptenus;* that genus is now a synonym of *Calliptamus* and likewise is limited to the Old World. Scudder's 1897 Revision of the Melanopli is a landmark in the study of the grasshoppers of this group. The species he assigned to *Melanoplus* were arranged in 28 groups which he called "series". Later, Hebard made notable contributions to the knowledge of *Melanoplus* and its allies, including a special series of papers which began in 1918 and continued for about 20 years, followed by an unpublished arrangement of the numerous species. He modified the "series" of *Melanoplus* used by Scudder and recognized 45 species-groups.

Partly because the pioneer authors placed the species of *Melanoplus* in genera which were based primarily on European species, it was then often thought that the chief relatives of *Melanoplus* occurred in the Old World. However, in 1958 James Rehn, following a life-time studying Orthoptera, concluded that *Melanoplus* and many related genera probably originated within North America. He did think that certain genera, such as *Bradynotes* and *Zubovskya* (which later was recognized in North America as a distinct genus *Boonacris)* had basic Old World relationships. Most of the genera with close Old World ties were listed by Rehn & Randell in a preliminary 1963 paper on generic grouping as members of the tribe Podismini rather than the restricted tribe Melanoplini.

Refined study of male genitalia constitutes a comparatively new tool for a more discriminating definition of the genus *Melanoplus* than has yet been produced. With the increased collecting and larger samples of species, coupled with the further advantage of automatic data processing equipment, it is now possible to make a more thorough

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investigation of the generic units at present encompassed under the single generic name *Melanoplus*. Only a few isolated species or small species-groups already have been removed, such as the former *Melanoplus militaris* (Scudder), now in the genus *Argiacris* together with 3 other species which never were placed in *Melanoplus*. *Melanoplus frigidus* (Boheman) is the basis of the genus *Bohemanella* and occurs in extreme northern North America as well as parts of northern Europa and Asia, a truly holarctic species. Some specialists have recognized the validity of *Bohemanella;* others have not done so. It is my opinion that there should be some more division of the species now comprising *Melanoplus*, but I hope that it will be done conservatively, without undue "splitting".

For some 20 years I have been interested in various species-groups of *Melanoplus* and have published papers in an attempt to clarify several of them. Unfortunately, other interests and duties have prevented a concentrated study across the whole genus and its allies such as they deserve. Intermittently for about 10 years, and including 3 collecting trips in the prime occupied area, I have studied the *montanus* species-group of *Melanoplus*. There are 8 described species concentrated in Idaho and nearby states and Canadian Provinces near Idaho. They occur typically at altitudes of about 5,000 feet (1,500 meters) or more, in openings or clearings surrounded by basically coniferous vegetation. One species, *M. daemon* Strohecker, was found by Banfill & Brusven in 1973 to feed chiefly on forbs such as *Lupinus*. In the Seven Devils area of western Idaho they considered *daemon* well adapted to "early and intermediate seral stages in the mountain-meadow region ..." The seral stages represent periods in the process of plant succession. I have no other exact data on food plants of *montanus* group species. These grasshoppers are all brachypterous, have red hind tibiae, and, althougth the male cerci of certain species show minor differences, most of the species are comparatively similar externally.

Collecting of this group has yielded what I at first regarded as about 30 segregates suspected of being distinct species. The structures of the aedeagus supply the most distinctive characters for separating the segregates. Later, in some cases after a lapse of 2 or more years, more critical study suggested that only about 18 species, including the 8 described ones, are distinct. There is some geographic overlapping of 2 or more species, but in most areas only one species of the group occurs. Members of the *indigens* species-group of *Melanoplus* (a complex of brachypterous species with greenish-gray hind tibiae and a pattern of aedeagal structures and male cerci different from the *montanus* group) frequently occur in company with one of the *montanus* group.

The 18 species may be divided roughly into subgroups, and one or two species are markedly distinct from any of the others. The illustrations (not included with this summary) prepared to accompany the discussion of these grasshoppers explain the distribution patterns and the aedeagal characters utilized. One species, *M. idaho* Hebard, is represented only by the unique male holotype, and although I went with several other collectors to the vicinity of the type locality in 1969 I was unable to find the insect. There is at least a fairly adequate sample of all other species.

I would like to emphasize that the synopsis of the *montanus* species-group which I am preparing will be preliminary in character and will not have the final results which more collecting and refined methods of analysis will eventually permit.

In addition to more collecting at points intermediate between localities where samples already have been taken, to give evidence of a cline or other type of population relationship, there is a possibility of useful work with chromosomes and with hybridization studies of laboratory cultures. At present no critical comparisons of female genitalia have been made.

The important thing is that enough collecting has been done to demonstrate the occurrence of active speciation in the *montanus* group and that the aedeagus supplies a wealth of distinctive characters. Happily, the terrain in the North American Northwest where the species occur is a wonderful place to do field work.

ABSTRACT

METHODS TOWARD THE STUDY OF FEEDING BEHAVIOR: A FAUNAL APPROACH

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Acridologists have a good understanding of food-habits in several hundred grasshopper and locust species from which can be extrapolated generalizations relative to the subordinate taxonomic groups. Unfortunately, they know little of the insects' feeding on a faunal basis.

The food-habits of Acrididae are best studied throungh a battery of methods, including (1) analysis of mandibular adaptation (graminivorous type, forbivorous-type, and herbivorous-type adaptations are readily recognizable); (2) analysis of crop contents (trichomes, guard and subsidiary cells, and specialized epidermal cells are diagnostic, sometimes to the specific level, particularly in the case of limited, known florae); (3) field observations of feeding (often more useful for other orthopteroids than for grasshoppers); and (4) differential feeding tests (which disclose food preferences, with the factor of food availability canceled out).

The detailed, battery approach outlined above involves an expenditure of time and effort that most acridologists on field excursion find prohibitive. The uncomplicated "Rapid Survey Method", which can be carried out with minimal effort during standard collecting, is more suited to their needs. The "Rapid Survey Method" involves individual tubes fashioned of cut newspaper into which living grasshoppers are thrust. The insects defecate often until killed 12-24 hours later. They are then available for standard taxonomic study after their mouthpart adaptation has been determined. The feculae are harvested for determination of gross form and for cytologic analysis of the content.

The results may be presented in a series of bar graphs summarizing feeding in the fauna. These graphs may be compared with similar graphs for other faunae.

THE VALUE OF CYTOLOGY IN TAXONOMY WITH PARTICULAR REFERENCE TO THE PODISMINI (ACRIDOIDEA: ACRIDIDAE: MELANOPLINAE)

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M.J.D. White, working in the United States in the 1940's and early 1950's and subsequently in Australia from 1954 to the present, has been the main driving force in promotion of use of cytology in systematics, particularly of Orthoptera. Use of cytology in systematics of the group is not new; McClung (1908, 1914) and others studied chromosomes of Orthoptera and Robertson (1916) developed a rather good treatise on many species of Orthoptera.

More recently, White has carried out a very comprehensive survey of the Morabine grasshoppers of Australia (Orthoptera: Eumastacidae) which enabled Key (1976) to complete the work on generic and suprageneric classification of the group. Forty genera are now recognized in the Morabinae (36 of which were new) and 33 new species were described. One of the more interesting aspects of this work is that karyotypic characters were used in a numerical analysis, together with dimensional and meristic characters and those of the phallic complex.

White (1970) stated that the Eumastacoidea showed a greater diversity of karyotypes than the Acridoidea, each subfamily of the former usually showing a different typical karyotype.

Karyotypes are useful in themselves and it is becoming rather common to see karyotypes or even more often the number of male diploid chromosome complement listed in species descriptions. In fact, karyotype can be used in precisely the same way as shape of the genitalia as a taxonomic character. However, since "evolution is a cytogenetic process" (White 1970) one usually will delve deeper into the study of chromosome structure and behaviour. The basic number, "modal number" or "nombre fondamental" of chromosomes in Acrididae is said to be 2n ♂=23, meaning that there are 11 pairs of autosomes and a single X or sex-determining chromosome. In many genera, this is the case. However, we know that in the Acrididae there occur 13 different chromosome numbers, ranging from 23 to 8. The numbers less than 23 are the result of chromosome fusions or chromosome deletions which have occurred during species evolution. Species which have even-numbered complements in the males (*i.e., 2n ♂ = 22* or *2n ♂ = 8* are ones in which the X-chromosome has undergone fusion with autosome resulting in neo-XY sex chromosome makeup rather than the original XO (White, 1970; Hewitt and John, 1972).

While karyotypes are useful, they cannot be used to distinguish between many known genera (*i.e.*, very many have a complement of 2n ♂ = 23). Careful examination of the chromosomes making up these karyotypes often will provide valuable information. Careful measurements may show differences between species in lengths of comparable chromosomes. Spectrophotometric analysis to measure amount of DNA present may reveal differences (John and Hewitt 1966). One useful character, one that has been found to vary greatly even in closely related species, is the length of the small second arms of acrocentric chromosomes.

Since we are concerned with variation, the study of polymorphic chromosomal rearrangements is useful, though sometimes confusing in that populations may contain individuals with slightly differing karyotypes.

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P.G. Fontana, a former student of White, and more recently a student under my direction, worked on cytology of North American orthopteroids, and in particular on three genera of eastern North American grasshoppers, *Boonacris, Dendrotettix* and *Appalachia* (Acrididae; Melanoplinae; Podismini). Thirteen populations of 2 species of *Boonacris,* one with 3 subspecies, were studied and compared with representatives of the other two genera.

In general the eastern populations of *Boonacris,* which included *B. variegata* (Scudder), *B. glacialis glacialis* (Scudder), *B. glacialis canadensis* (E.M. Walker) and *B. glacialis amplicerca* (Caudell and Allard), showed a high degree of karyotypic stability. The standard karyotype of these eastern *Boonacris* species is 20 telocentric autosomes; the sex-determining mechanism is the XO/XX type. The autosomes occur as 2 long, 6 medium and 2 short pairs; the X-chromosome is the third largest member of the complement. The amount of intra -and inter- population variation is quite similar to that observed between taxa. The length of each member of the chromosome complement is extremely stable and could not be used to differentiate between species of subspecies. A single B-chromosome was found in a small proportion of individuals of each sex of a population of *Boonacris variegata* (Scudder) from Mt. Mitchell, North Carolina. No supernumerary chromosome was found in any of the other populations of *Boonacris.*

TABLE 1.

Assignment of genera in tribal groupings by Rehn and Randell (1963, pp. 10–11)

Compare With Table 2

Supertribe Melanoplini
Tribe Podismini

1. Group Podismae

Micropodisma
Zubovskya
Boonacris
Dendrotettix
Appalachia
Eirenephilus
Ognevia
Podisma
Bohemanella
*Odontopodisma**
*Pseudopodisma**
*Yunnanacris**
*Niitakacris**

2. Group Miramellae

Indopodisma
Oropodisma
Cophopodisma
Epipodisma
Miramella
Chortopodisma
Parapodisma
Sinopodisma
*Pseudoprumna**

3. Group Bradynotae

Hypsalonia
Hebardacris
Argiacris
Buckellacris
Kingdonella
Asemoplus
Bradynotes

4. Group Primnoae

Primnoa
Prumnacris
Pachypodisma

**Atypical*

TABLE 2.

Proposed assignment of genera of the Podismini to subtribal groupings (Based upon known cytogenetic data of the species)

Subfamily Melanoplinae
Tribe Podismini

1. Subtribe Podismina (2n ♂ = 22+ X0)	2. Subtribe Miramellina (2n ♂ = 20+ X0)
Podisma	*Miramella*
pedestris pedestris	*alpina*
pedestris melisi	*Boonacris*
pedestris caprai	*glacialis glacialis*
pedestris dechambrei[1]	*glacialis canadensis*
emiliae	*glacialis amplicerca*
Cophopodisma	*variegata*
costai	*Parapodisma*
Dendrotettix	*mikado*
quercus	*dairisama*
Appalachia	*Sinopodisma*
arcana[2]	*shirakii*[2]
(Parapodisma?)	*splendida*[2]
sapporensis	*kodamae*[2]
	Niitakakris
	nosaceanum
	(Podisma?)
	motodamariensis

1 Some populations have male complement 20 + neo XY, due to X–L3 fusion.

2 Some chromosomes acrocentric. All others in all species are telocentric.

medium and 3 short pairs. Two males were found to have B-chromosomes; one had a single B, while the other had 2 Bs. In both cases the Bs were small but highly stable, but behaved differently than those found in *Boonacris variegata,* being isopycnotic with the autosomes at 1st metaphase rather than negatively heteropycnotic as in *B. variegata.*

The chromosome complement of the unique endemic species from Michigan, *Appalachia arcana* Hubbell and Cantrall, is rather similar to that of *Dendrotettix quercus,*

TABLE 3.

Karyotypes of some genera of Nemobiinae.

	2nσ Karyotype
EUROPE:	
Nemobius	
N. sylvestris Bosc.*	17
NORTH AMERICA	
Neonemobius	
N. palustris (Blatchley)	19
N. variegatus (Bruner)	19
Pictonemobius	
P. ambitiosus (Scudder)*	19
Allonemobius	
A. fasciatus (De Geer)*	15
A. allardi (Alex. & Thomas)	15
A. maculatus (Blatchley)	15
A. g. griseus (E.M. Walker)	15
A. tinnulus (Fulton)	15
Eunemobius	
E. carolinus carolinus (Scudder)*	7
E. melodius (Alex. & Thomas)	7
E. confusus (Blatchley)	7

*Type species of the genus.

male-23, female-24 chromosomes; 2 large, 6 medium and 3 short autosomes; single X ranking third in size. However, the similarity is superficial as three major differences between them were found. In *A. arcana,* the short arms are considerably longer than in any other of the taxa which were studied (in fact, the S10 is unusual in being a genuine acrocentric (two-armed pair) and overall lengt was greater; S10 is heterochromatic and precociously heteropycnotic at prophase I; mean cell chiasma frequency is much greater.

It is clear that the differences in chromosome complements separates the taxa studied into two groups: (1) *Boonacris* with 2n σ = 21 and (2) *Dendrotettix* and *Appalachia* with 2n σ = 23. It appears obvious, on morphological and other grounds, that

the genera are related and are derived from common basic stock from which the contemporary genus *Podisma* has differentiated only slightly. This brings the problem of different complements into focus: finding an explanation for the difference made necessary a study of the entire podismoid complex, or at least those members for which cytological information was available in literature. It soon became apparent that the "podismoid complex" is composed of two groups, one with male 2n ♂ = 21 and the other with male 2n ♂ = 23 chromosome complements. The group with male diploid complement of 21 chromosomes is obviously derived from the 23 chromosome group. The difference, probably caused by chromosome deletion, certainly took place early in the evolution of podismoid stock, probably prior to the expansionary phase of the ancestral Asiatic stock. It is highly improbable that the species with 21 chromosomes have originated independently by means of separate chromosomal rearrangements involving different autosomes. In fact, the available data show that in the 21-chromosome species it is always the smallest autosome pair (S11) which is missing. There is convincing evidence that elimination of small, unstable heterochromatic autosome pairs and subsequent fixation of a lesser chromosome number in the basic karyotype is a relatively common phenomenon (Gustavsson and Sundt, 1967). In fact, in the genera we studied, it is apparent that the relative lengths of the autosomes in the 21-chromosome group is greater than the lengths of the equivalent autosome pairs of the 23-chromosome group. This indicates that the pair of autosomes which is missing in the 21-chromosome group is not, in fact, lost, but that their chromatin material has been added to other autosomes. In many grasshoppers, the small autosomes occur as heteromorphic pairs due to disparities in the amounts of heterochromatin (occasionally, as in *Calliptamus* and others, they may form univalents; White 1973). Also, we found that some of the small autosomal pairs in the podismines are largely heterochromatic, precocious and occasionally asynaptic at meiosis, and so are prone to non-disjunction and polysomy.

The evidence then clearly indicates an early loss of an autosomal pair in certain of the podismine ancestral stock, followed by evolutionary development into specific and generic components in eastern Asia. Rehn and Rehn (1939) and Rehn (1950) stated that eastern Asia was undoubtedly the region where the greatest differentiation of the podismoid assemblage occured, and is the region where a large number of genera are found in present times.

Early, pre-glacial migration into North America seems to be indicated by the present distribution in that continent, two widely separated areas, one eastern, mainly Appalachian, and the other western, in the Cascade, Sierra Nevada and Coast Ranges of mountains. In the Palaearctic Region, the present distribution also shows the effects of glacial influences (Hewitt and John 1972). The early split into differing karyotypes makes it possible to arrange the genera of the Podismoid complex into two tribes, in which the relationships of members of a tribe is greater than with members of the other tribe, in other words a tribal arrangement which is truly phylogenetic. Fossil evidence is not available, but the cytological evidence clearly is sufficient.

Rehn and Randell (1963) proposed a tribal classification for the Podismoid group. Their classification appears to be based entirely on arbitrary evaluation of phenetic similarities and to be biased by the historical categorization of the taxa in question (see also comments by Cohn and Cantrall 1974, p. 18). Although cytogenetic knowledge of the Podismoid group is still incomplete, present data indicate clearly that the groupings of Rehn and Randell are phylogenetically heterogenous. Genetic homogeneity in groupings is the essence of an evolutionary classification.

Table 1 shows the assignment of Podismoid genera to various tribal groupings by Rehn and Randell (1963). They recognized a Supertribe, the Melanoplini, a Tribe Podismini, with inferior categories, which they called groups. In fact, the "Groups" should have been called "Subtribes" with appropriate "ina" subtribal suffixes instead of the meaningless "ae" suffixes which they employed.

Table 2 shows the proposed Tribal classification for the group for those species which are known cytogenetically. Only 9 genera can be assigned at present but even within the limited number shown in Table 2, it is apparent that cytological evidence makes possible much more precise assignment at tribal and generic levels. Among the species listed in Table 2, it is evident that some generic reassignment is necessary.

Parapodisma clearly belongs in the 21-chromosome group, but the species, *sapporensis*, which has been included in *Parapodisma* has 2n ♂ = 23 chromosomes. Similarly, *Podisma* belongs in the 23 chromosome group and the species *motodomariensis*, which has only 2n ♂ = 21 chromosomes, clearly does not belong in the genus *Podisma*.

This indicates that chromosome number alone can assist in recognition of relationships between genera and even within certain supposedly stable generic entities. When chromosome structure, configuration and behaviour are included, we must acknowledge that cytological study has certainly not been used to full advantage. Part of the reason for this is the great difficulty in obtaining specimens, which are properly fixed for cytological study, from a geographical area large enough to encompass whole tribes or even genera, within our limited resources of time and money.

An ideal situation might be one in which the whole of the Podismini might be studied and compared at the same time. On a somewhat smaller scale, geographically but not numerically, a complete cytological study of the genus *Melanoplus* could be quite rewarding and very useful in revising the genus, a task long overdue.

It may be noted here that we recognize the Melanoplinae as a subfamily of the Family Acrididae and consider the Podismini as a tribe in the Melanoplinae, rather than as a subfamily (Podisminae) as recognized by Dirsh (1975).

It may perhaps be interesting to close on a note from another group of orthopteroids, the crickets of the Subfamily Nemobiinae. For most of the Order Grylloptera, katydids, bush crickets and crickets, there is no "modal number". In Acrididae a modal number of 2n ♂ = 23 is found very widely. In nemobiine crickets at least, the chromosome number, although much more variable, seems to be fixed at generic level. Hebard (1913) divided the genus *"Nemobius"*, as he called it, in North America into subgenera but the names of the subgenera were not used or recognized for many subsequent years. In 1970, Vickery and Johnstone pointed out that no North American species actually belonged in the genus *Nemobius* and, therefore, established the names proposed by Hebard at generic level. The karyotypes of these genera are interesting (Table 3). The type species of *Nemobius, N. sylvestris* Bosc has a chromosome complement of 2n ♂ = 17 (Favrelle, 1936). One of our students, Lim (1971), showed that three of the North American genera had quite different karyotypes, *Allonemobius*, 2n ♂ = 15; *Neonemobius*, 2n ♂ = 19; *Eunemobius*, 2n ♂ = 7. The genus *Pictonemobius* Vickery and Johnstone also has a 2n ♂ = 19 complement, but its karyotypic configuration is different from the others having the same chromosome number.

It is suspected that chromosome loss has been independent in the generic groups. It appears that a diploid male complement of 19 chromosomes is the base number, i.e., the primitive number, and that repeated alterations in configurations have produced the genera having fewer chromosomes. It is also apparent that the genus *Nemobius*, the type genus of the subfamily, is not typical for the subfamily in terms of karyotype or morphologically or behaviourally, as was pointed out by Vickery & Johnstone (1970).

It can be seen, therefore, that the chromosomes of orthopteroids can provide a great deal of information, much of which is taxonomically significant.

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ABSTRACT

THE VALUE OF ISLANDS AS INDICATORS OF EVOLUTION: THE GRASSHOPPERS OF THE CALIFORNIA CHANNEL ISLANDS

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Twelve of 54 Orthoptera species (22.2 o/o) found on the eight California Channel Islands off the coast of southern California are endemic, 11.9 o/o in the northern four-island group and 22.2 o/o in the southern four-island group.

A general analysis of the distribution of these endemics, especially those in the cricket genus *Cnemotettix* and those endemic species capable of flight, was conducted.

The results indicate that autochthonous speciation, and not the occurrence of mainland relicts, explains these high endemic numbers. A regression analysis of long island area versus long number of Orthoptera species yields results similar to those of other animal and plant species. Faunistically rich land masses that lie within 20 km of one Channel Island are disproportionately more important as source areas than those land masses whose distances exceed 20 km.

Simple regression of enviromental components correlated with faunal diversity shows that for untransformed data, orthopteran species numbers are significantly explained by area (82 o/o) and elevation (74 o/o). For long transformed data, the significance of area explaining orthopteran species number is diminished to 57 o/o, while elevation explains 78 o/o which is almost unchanged from before transformation.

NOTAS PARA UNA REVISION DE LA SUBFAMILIA OMMEXECHINAE. VIII. EL GENERO *OMMEXECHA* SERVILLE (ORTHOPTERA, ACRIDIOMORPHA)

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SUMMARY. *Notes for a revision of the subfamily Ommexechinae. VIII. The genus* Ommexecha *Serville (Orthoptera, Acrididae, Ommexechini).*

The genus *Ommexecha* Serville and all the known valid species are redescribed and figured, on the basis of abundant series of the distribution area, also stablishing the following synonimous: *O. servillei* Blanchard and *O. germari* Burmeister = *O. virens* Serville; *O. caerulans* Bolivar = *O. macropterum* Blanchard and *O. walkeri* Kevan = *O. gracilis* Walker.

A key for the identification of the mentioned species, and biogeografics comments are added.

Dentro de los géneros que integran esta subfamilia, es el género *Ommexecha* Serville 1831, el que ha sido más profusamente mencionado en la literatura acridiológica desde su creación.

A la especie tipo del género, *O. virens* Serville, se incorporan sucesivamente nuevos taxa; *O. macropterum* Blanchard, 1836, *O. gracilis* Walker, 1870, *O. servillei* Blanchard, 1836, *O. germari* Burmeister, 1838, *O. brunneri* Bolivar, 1889, y *O. giglio-tosi* Bolivar, 1889, además de otros hoy incluidos en distintos géneros que integran esta subfamilia (*Spathalium* Bolivar y *Descampsacris* Ronderos).

El haber tenido acceso a los materiales típicos y haber contado con abundantes series representativas de amplios sectores de su ámbito de dispersión, nos ha permitido encarar la revisión de este género, cuyos resultados se exponen a continuación.

Queremos dejar expresado nuestro agradecimiento a las siguientes personas que nos ha permitido el acceso a las colecciones bajo su custodia o han facilitado materiales para su estudio: Dr. M. Descamps, Museum D'Histoire Naturelle, Paris; Dr. Eugenio Morales Agacino, Instituto Español de Entomología, Madrid; Prof. Carlos S. Carbonell, Montevideo, Uruguay; Dr. H. Radclyffe Roberts, Academy of Natural Sciences, Philadelphia, USA; Dr. I.J. Cantral, Museum of Zoology, University of Michigan, Ann. Arbor, USA; Dr. David R. Ragge, British Museum (Natural History), Londres; Sr. Manuel Viana, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Buenos Aires y R.P. Gregorio Williner, Instituto Entomológico San Miguel (San Miguel, Buenos Aires).

Género Ommexecha Serville

Ommexecha Serville, *Ann. Sci. Nat. Paris*, 22: 285; 1839, *Hist. Nat. Ins. Orthop.* p 696; Bruilé, 1835, *Hist. Nat. Ins.*, 9: 229; Blanchard, 1836, *Ann. Soc. Ent. France* 5: 607; 1840, *Hist. Nat. Ins.* 2: 26; Burmeister, 1839, *Handl. Entom.* 2: 653; Stal, 1873, *Recensio Orthop.* 1: 119; Bolivar, 1884, *An. Soc. Española Hist. Nat.*, 13: 21-27; 1899, *Rev. Chilena Hist. Nat.*, 3: 54; Kirby, 1890, *Proc. R. Dublin* Soc. 6: 592 Bruner, 1900, *2nd. Rep. Merch. Loc. Bs. As.*, p. 47; 1906, *Proc. U.S. Nat. Mus.*, 30: 639; Liebermann, 1928, *An. Soc. Cient. Argentina*, 104: 146; Rehn, 1938, *Proc. Acad. Nat. Sci. Philad.* 90: 127 Kevan, 1953, *Entom. Month. Mag.*, 89: 221-223; Dirsh, 1961, *Bull. Brit. Mus.*, 10 (9): 381; Eades, 1961, *Proc. Acad. Sci. Philad.*, 113: 168; Gurney y Liebermann, *Proc. Biol. Soc. Wash.*, 76: 135-137.

1910 – *Ommexycha* Kirby, *Synon. Cat. Orthopt.* 3: 296.
Tipo del género *Ommexecha virens* Serville.

Redescripción genérica

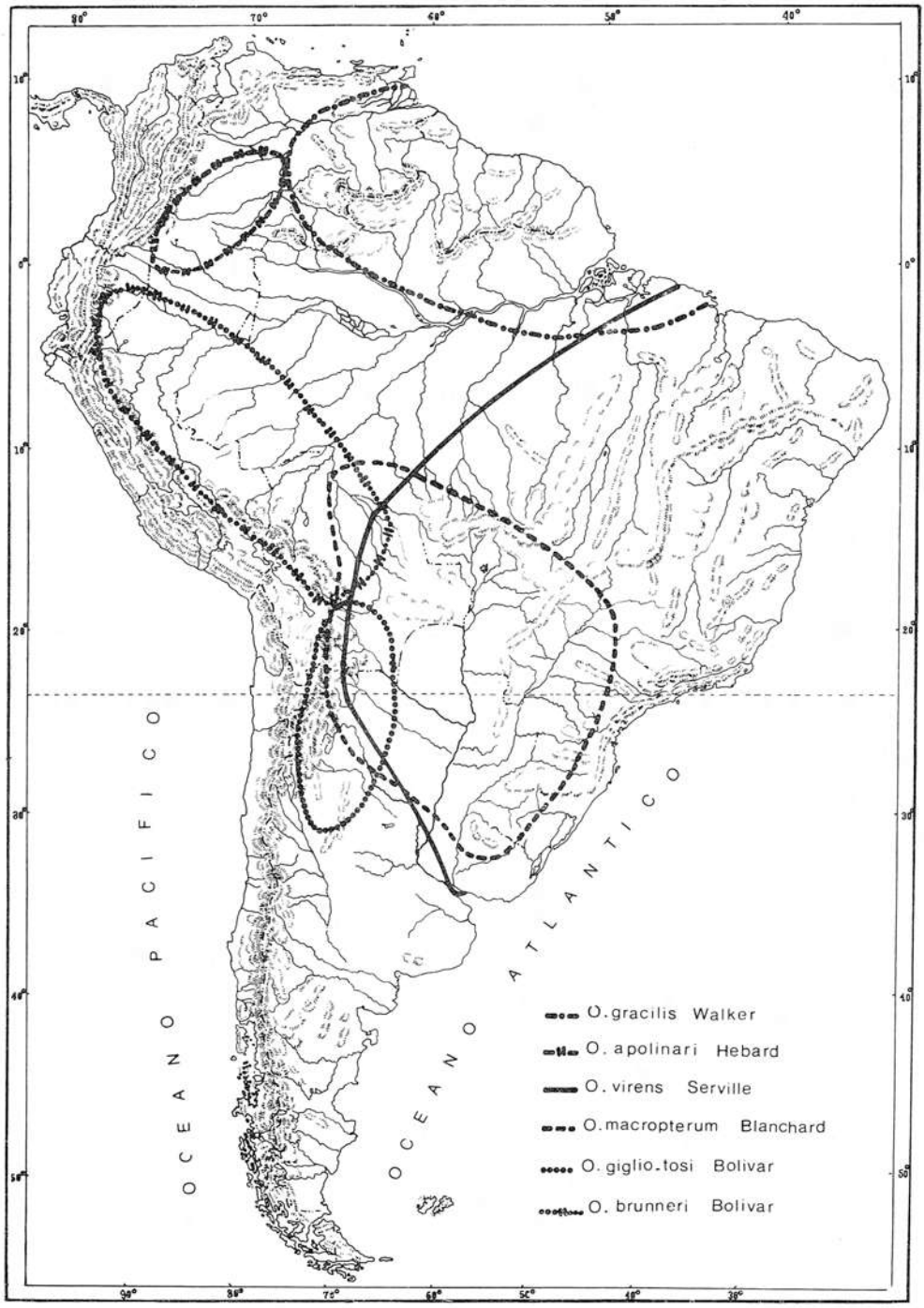
Tanto la descripción original como la redescripción del género que realiza Blanchard (1836) incluyen caracteres comunes a otros géneros hoy integrantes de esta subfamilia, lo que nos obliga a su redescripción a fin de precisar aquéllos que le son propios.

Insectos gráciles con tegumento glabro y tuberculado. Cabeza con frente oblicua; fastigio prominente, tan largo como el escapo, o escapo y pedicelo reunidos, netamente sulcado dorsad, sulcado que se continúa en la costa frontal sin interrupción hasta el ocelo medio; ésta con carenado lateral neto no más allá del ocelo impar. Ojos globosos, prominentes laterad y dorsad, superando ampliamente el vértice.

Tórax con pronoto subrectangular, con escasa expansión lateral de sus lóbulos laterales; surcos transversos enmarcados por los tubérculos a excepción del principal que es bien evidente; prozona y metazona subiguales en longitud; carena mediana longitudinal tuberculada en la prozona, lisa en la metazona. Prosterno con una pequeña prominencia mediana tuberculiforme; espacio intermesosternal amplio, más ancho que largo. Tégmenes delgados, superando ampliamente al abdomen en ambos sexos (con excepción de *O. virens* en su forma braquíptera) con su ápice delgado; alas normales con tintes variados, patas gráciles, tuberculadas, sin expansiones foliares dorsales y laterales, sólo con un serrulado variable en extensión, en su borde dorsal; rodillas con un par de tubérculos (dorso-apicales) espiniformes de desarrollo variable. Abdomen normal; segmentos genitales en ambos sexos con epiprocto triangular con un surco transverso mediano; placa subgenital, en los machos triangular de ápice agudo; en las hembras con guía del huevo prominente y un sólo par de columelas, escleritos postvaginales reducidos.

Complejo fálico, en los machos, como en el resto de los géneros de la tribu Ommexechini (*sensu* Eades, 1961); espermateca, en las hembras, con expansiones digitiformes y ducto amplio, saculiforme, con una expansión mediana bulbosa.

Los integrantes de este género presentan una coloración muy uniforme en la gama del castaño, yendo del castaño claro amarillento al castaño oscuro, siendo siempre más clara en los esternos tanto toráxicos como abdominales. No son frecuentes, pero si presentan principalmente en poblaciones de *virens, giglio-tosi, gracilis,* y *brunneri* formas con tegumento verde, pero siempre con tonalidades castaño. Las alas según las especies pueden presentarse incoloras o azules *(macropterum),* amarillo o verde amarillento *(apolinari, brunneri, giglio-tosi y gracilis)* o castaño oscuro *(virens),* coloración que siempre se atenúa hacia el borde posterior del ala.


O C E A N O P A C I F I C O
O C E A N O A T L A N T I C O
O. gracilis Walker
O. apolinari Hebard
O. virens Serville
O. macropterum Blanchard
O. giglio-tosi Bolivar
O. brunneri Bolivar

Mapa de destribución de las especies del género *Ommexecha* Serville.

Clave para la identificación de las especies del Género *Ommexecha* Serville

1 – Proyecciones geniculares de los fémures posteriores nulas o escasamente desarrolladas 2
– Proyecciones geniculares de los fémures posteriores netas, espiniformes 3
2 – Mancha basal de la página interna de los fémures posteriores negra o castaño oscuro; insectos braquípteros o macrópteros, alas castaño oscuro ..... *virens* Serville
– Mancha basal de la página interna de los fémures posteriores rojo claro o rosada; insectos macrópteros, alas amarillas ..... *giglio-tosi* Bolivar
3 – Alas amarillas 4
– Alas azules o incoloras; espacio interocular más ancho que el ancho máximo de un ojo en vista dorsal ..... *macropterum* Blanchard
4 – Apice de los tégmenes con el borde costal no aguzado, redondeado; fastigio netamente declive ..... *apolinari* Hebard
– Apice de los tégmenes con el borde costal aguzado; fastigio levemente declive 5
5 – Espacio interocular más ancho que el ancho de un ojo en vista dorsal *brunneri* Bolivar
– Espacio interocular tan ancho como el ancho de un ojo en vista dorsal *gracilis* Walker

Ommexecha virens Serville
(figs. 18 a 23)

1831 – *Ommexecha virens* Serville, *Ann. Sci. Nat. Paris 22:* 286; 1839, *Hist. Nat. Ins. Orthopt.:* 701; Blanchard, 1836, *An. Soc. Ent. France, 5:* 612; Burmeister, 1839, *Hand. Entom., 2:* 655; Walker, 1870, *Cat. Derm. Salt. Brit. Mus. 4:* 798; Bolivar, 1884, *An. Soc. Española Hist. Nat., 13:* 29; 1899, *Rev. Chilena Hist. Nat.,* 3: 56; Bruner, 1900, *2nd. Rep. March. Loc. Bs. As.:* 47; 1906, *Proc. U.S. Nat. Mus., 30:* 639; 1910, *Ent. News,* 21: 302, Rehn, 1907, *Proc. Acad. Nat. Sci. Philad.:* 168; 1911, *Ent. News, 22:* 251; Liebermann, 1937, *Rev. Chilena Hist. Nat.,* 41: 55; 1939, *Rev. Soc. Ent. Argentina,* 10: 165.

1910 – *Ommexycha virens:* Kirby, *Synon. Cat. Orthopt., 3:* 297.

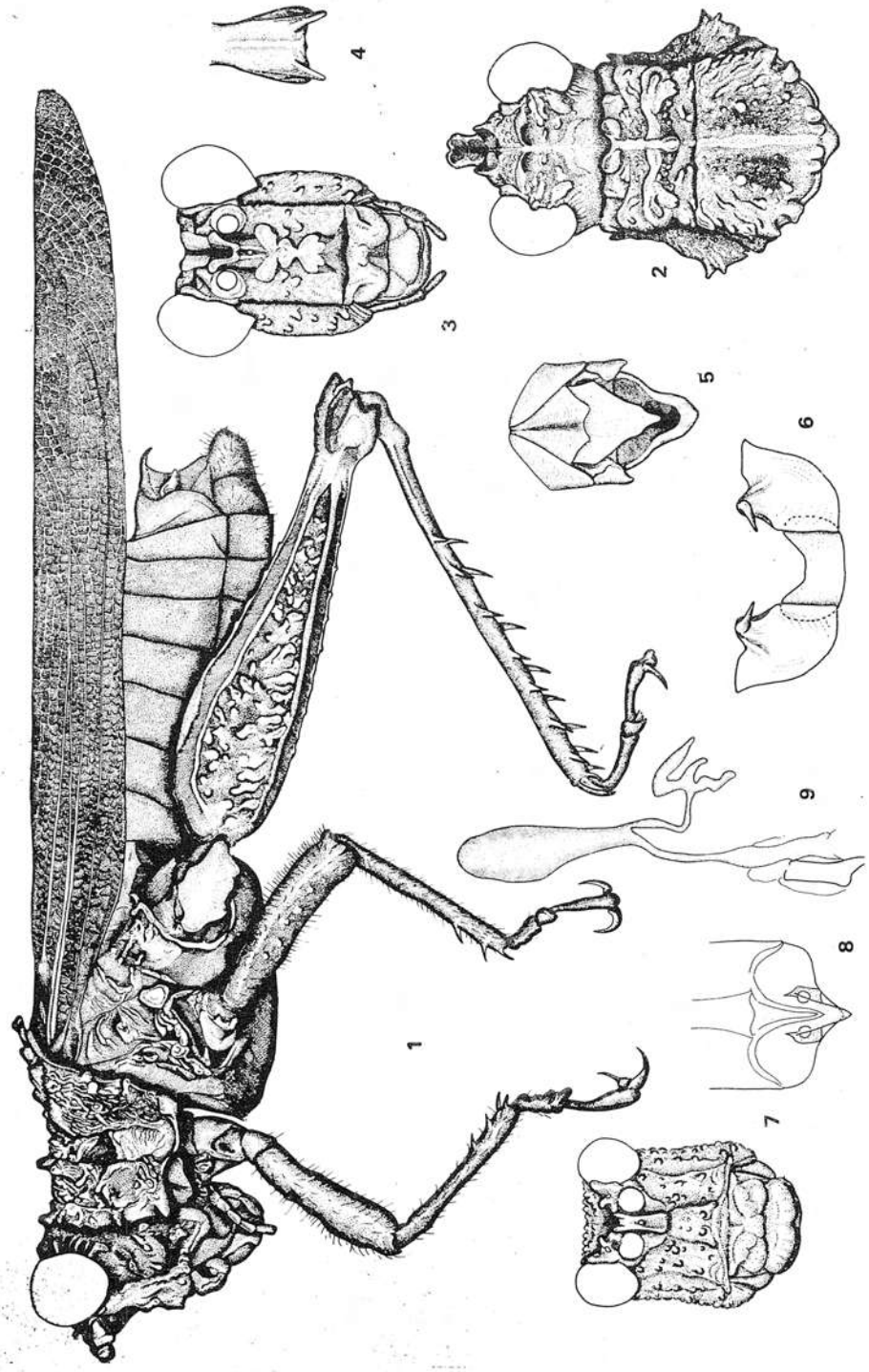
1836 – *Ommexecha servillei* Blanchard, *Ann. Soc. France,* 5: 613; Serville, 1839, *His. Nat. Ins. Orthopt.:* 701; Walker, 1870, *Cat. Derm. Salt. Brit. Mus. 4:* 720-798; Bolivar, 1884, *An. Soc. Española Hist. Nat.., 13:* 29; 1899, *Rev. Chilena Hist. Nat.: 3:* 56; Giglio-Tos, 1894, *Zool. Jahrb., 8:* 812; *Bull Mus. Zool. Anat. Comp. Univ. Torino, 9*(184): 15; 1900 ibidem 15 (377): 3; Bruner, 1900, *2nd. Rep. Merch. Loc. Com. Bs. As.:* 47; 1906, *Proc. U. S. Nat. Mus., 30:* 639; 1910, *Ent. News. 21:* 303; 1911, *Ann. Carnegie Mus., 8:* 39; 1913, ibidem 8: 460; 1919, *Ann. Carnegie Mus., 13:* 35; Rehn, 1908, *Proc. Acad. Nat. Sci. Philad.:* 12; 1913 ibidem *65:* 328; ibidem *67:* 283; 1918, *Trans. Amer. Ent.Soc.* 44 (779): 196; Liebermann, 1939, *Rev. Soc. Entom. Argentina:* 10: 164; 1941, *Publ. Min. Just. Instr. Publ. Paraná, Entre Rios Argentina:* 36; 1945, *Acta Zool. Lilloana 3:* 237; 1946, *Rev. Entom. 17:* (3): 455; *Rev. Soc. Ent. Argentina* 14: 106; 1949, *IDIA 15:* 14; 1950, *Rev. Brasil Biol. 10* (1): 138; 1951, *IDIA 42:* 47; 1955, *Mem. Inst. Oswaldo Cruz,* 53: 334; 1958, *INTA, Inst. Pat. Veg. Publ. Tecn., 5:* 22; 1967, *Physis, 26:*(73): 504; Baucke, 1954, *Secr. Est. Negoc. Agric. Industr. Com.* Ser. Divulg.*10:* 6; Liebermann y Pirán, 1941, *Dir. Gen. Lucha Langosta,* Montevideo: 9; Liebermann y Ruffinelli, *Rev. Asoc. Ing. Agron. Montevideo,* 47: 17; Dirsh, 1956, *Trans. R. Ent. Soc. London, 108:* 274; 1961, *Bull. Brit. Mus. 10* (9): 383; 1968, *EOS 43:* 469; Mesa, 1956, *Agros* 141: 40; 1963, *Rev. Soc. Uruguaya Ent. 5:* 38, 39, 41; Silveira Guido et al., 1958, *Publ. Fac. Agron. Montevideo:* 457; Eades, 1961, *Proc. Acad. Nat. Sci. Philad., 113:* 170 *(Nueva Sinonimia).*

1839 – *Ommexecha servillii:* Burmeister, *Handb. Entom.* 2: 656.

1910 – *Ommexycha servillei:* Kirby, *Syn. Cat. Orthop., 3:* 297

1839 – *Ommexecha germari* Burmeister, *Handb. Entom., 2:* 655; Walker, 1870, *Cat. Derm. Salt. Brit. Mus., 4:* Bolivar, 1884, *An. Soc. Española Hist. Nat., 13:* 28; 1899, *Rev. Chilena Hist. Nat. 13:* 28; 1899 *Rev. Chilena Hist. Nat., 3:* 36; Giglio-Tos, 1894 *Zool. Jahbr.,* 8: 812; 1894, *Boll. Mus. Zool. Anat. Comp. Univ. Torino, 9* (184): 15; 1900, ibidem *15* (184: 377; Bruner, 1906, *Proc. U.S. Nat. Mus. 30:* 639; Rehn, 1907, *Proc. Acad. Nat. Sci. Philad.;* 168; 1913, ibidem *65:* 328; *Trans. Amer. Ent. Soc., 44*.(779): 196; Liebermann, 1939, *Rev. Soc. Ent. Argentina, 10:* 164; ibidem, 1955, *Mem. Inst. Oswaldo Cruz, 53:* 334; Eades, 1961, *Proc. Acad. Nat. Sci. Philad., 113:* 70 *(Nueva sinonimia).*

1910 – *Ommexycha germari:* Kirby, *Synon. Cat. Orthopt., 3:* 297.



Ommexecha macropterum Blanchard. 1 a 6, ♂de Buena Vista, Bolivia (1, insecto adulto, vista lateral; 2, cabeza y pronoto, dorsal; 3, cabeza, frontal; 4; ápice del fémur posterior, dorsal; 5, segmentos genitales, dorsal; 6, epifalo). 7 a 9, ♀de Buena Vista, Bolivia (7, cabeza frontal; 8 placa subgenital; 9, espermateca).

Serville (1831), describe su *O. virens* en base a una hembra de "Buenos Ayres" sin mencionar una localidad precisa, limitándose la diagnosis a lo siguiente: "Yeux bruns, cuisses posterieures ayant en dedans, a leur base, un grande tache d'un noir luisant". Blanchard (1836), describe a *O. servillei* de Corrientes (Argentina), marcando diferencias con *virens* limitadas al color del tegumento y pubescencia, caracteres que son repetidos por Bolivar (1884) pero insinuando la posibilidad de que esta sea un sinónimo de *virens*. Burmeister (1839) describe a *O. germari* de Brasil, siendo la deferencia más sobresaliente mencionada respecto a las dos anteriores, el hecho de ser macróptera, coincidiendo en todos los demás caracteres tanto con *virens* como con *servillei*. Todas las menciones restantes en que se hacen comentarios respecto de estas especies (en claves o nuevas diagnosis) el carácter decisivo para su separación es su macropterismo.

El estudio de los tipos de estas especies así como series abundantes de su ámbito de dispersión nos ha permitido establecer la correspondiente sinonimia de *O. servillei* Blanchard y *O. germari* Burmeister con *O. virens* Serville.

Por lo arriba mencionado establecemos la diagnosis definitiva de esta especie como sigue: Insectos macrópteros o braquípteros, cuando macrópteros los tégmenes superan o no, levemente el ápice del abdomen, siendo su extremo redondeado. Tegumento en cabeza y pronoto con tuberculado denso; fastidio tan largo como el escapo antenal, con las carenas laterales prominentes, con una proyección espiniforme neta, más desarrollada en los machos. Ojos prominentes laterad, tan anchos como la mitad del espacio intercular. Pronoto con los lóbulos laterales netamente expandidos en su mitad inferior, con procesos espiniformes aguzados en los ángulos antero y postero-inferiores. Tégmenes y alas con desarrollo variable; los primeros, cuando reducidos, presentan un estrangulamiento neto en el borde costal, lo que les dá un aspecto sinuoso. Alas castaño oscuro más difuso en el borde posterior. Fémures posteriores con las proyecciones geniculares muy cortas, romas.

Segmentos genitales del macho con epiprocto triangular, levemente más largo que su ancho máximo; placa subgenital corta, aguzada bruscamente en el ápice.

Complejo fálico con epifalo con láminas laterales triangulares.

Segmentos genitales de la hembra sin caracteres distintivos significativos; placa subgenital similar a *O. giglio-tosi*.

Alas castaño oscuro; página interna de los fémures posteriores con una mancha castaño oscura o negra próxima a la base.

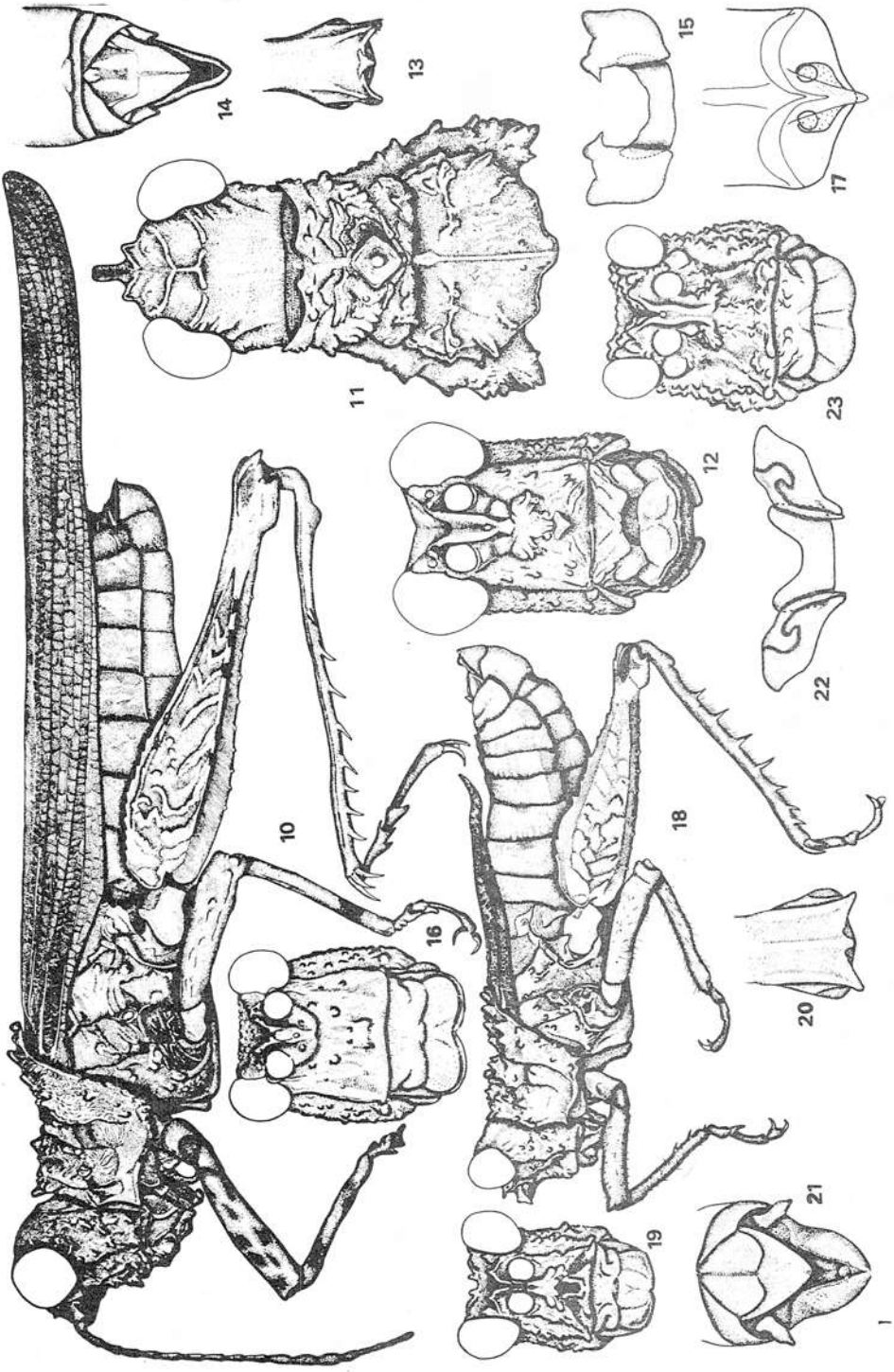
Material estudiado

Holotipo ♀: Buenos Aires*(MP); Ommexecha sevillei* Blanchard, Holotipo ♂: Prov. de Corrientes, D'Orbigny 1834; Alotipo ♀ ibidem, Paratipos 1 ♂ y 1 ♀ ibidem *(MP)*. **Argentinna:** *Misiones:* Ao. Uruguai, 1-10-III-70 Viana *(MBA))*; Co. Corá, 18-III-65, Carlos S. Carbonell y M. Monné *(FHC)*; Pto. Bemberg. J. Daguerre, III-34 *(MBA)*; San José, San Javier, G. Raimondo, 10-20-I-59 *(MLP)*; San Javier, I. Gregg *(MLP)*; Puerto Rico, V-60, Mauri *(MLP)* Iguazú, 15-XI-44, Birabén *(MLP)*; Olegario Andrade, IV-73, Fritz *(IESM)*; Loreto *(MBA)*; *Corrientes:* San Cosmé *(MBA)*; Manantiales, III-1946, Birabén *(MLP)*; Goya, IX-30, Bosq *(MLP)*; Bella Vista, II-31, Bosq *(MLP)*; Itatí, 15-III-39, Denier *(MLP)*; Pindapoy 21-8-60, Willink *(IML)*; Ituzaingó, II-75, Martinez *(MLP)*: *Chaco:* Fontana *(MBA)*; Resistencia, Meyer *(MBA)*. *Entre Rios*, Palmar Colón, I-76, Zelich *(MLP)*; Paraná, II-31, Daguerre *(MBA)*; Pronunciamiento, III-1964, Waltz *(ANSP)*. *Santa Fé:* Cayastá, 9-II-67, Bulla *(MLP)*; Santa Fé, IX-69, Schnack *(MLP)*; Reconquista, 26-XI-1939, Birabén *(MLP)*. *Formosa:* Herradura, 29-I-37, Denier *(MLP)*. *Salta:* Vespucio, XI-56, Orfila *(MBA)*. *Buenos Aires:* Isla Martín García, II-1939, Viana *(MBA)*.

Uruguay: *Artigas:* San Gregorio, 30-V-63, A. Mesa-C. S. Carbonell *(FHC)*.

Paraguay: Paraguarí, Escobar, 14-1-72-, Ronderos, Carbonell, Descamps *(MLP)*; San Estanislao, Williner *(IESM)*; San Pedro Ruta 3, 54 km. San Estanislao, 17-I-72, Ronderos, Carbonell, Descamps *(MLP)*; Cororó, Río Ipané, 25-I-65, Williner *(IESM)*; San Bernardino, 14-I-39, Denier *(MLP)*; Sapucay, 1925, Vanner *(MLP)*; San Lorenzo, Denier *(MLP)*; Igua Pindo, Williner *(IESM)*; Puerto Bertoni, Alto Paraná, Schnotteky *(ANSP)*; Villa Rica, Jorgensen, II-1922 *(ANSP)*; Horqueta, 45 km. E of Río Paraguay (57W 23N) I-27-1934, Schulz (ANSP), Ypacaray, 25-24-IX-1897, Bruner (MZM); Encarnación, Colonia; Bogado, Río Paraná and Vicenity, 28 oct. 1956, C. J. D. Brown *(MZM)*.

Bolivia: Santa Cruz, III-1952, Apostol (MBA); Chapare, Jungas, I-49, Williner (IESM); Santa Cruz de la Sierra, II-20 to 28, 1922, Steinbach *(ANSP)*; Buena Vista, 450 m, Steinbach *(ANSP)*.



10 a 17, *Ommexecha apolinari* Hebard. [10 a 15,♂ de Acacias, Colombia (10, insecto adulto, vista lateral; 11 cabeza y pronoto, dorsal; 12, cabeza frontal; 13, ápice del fémur posterior, dorsal; 14, segmentos genitales, dorsal; 15, epifalo). 16 y 17, ♀ de Villavicencio, Colombia (16, cabeza, frontal; 17, placa subgenital)]. 18 a 23, *Ommexecha virens* Serv. [18 a 22, ♂ de San Pedro, Paraguay (18, insecto adulto, vista lateral; 19, cabeza, frontal; 20, ápice del fémur posterior, dorsal; 21, segmentos genitales, dorsal; 22, epifalo); 23, ♀ de San Pedro, Paraguay, cabeza, frontal].

Brasil: Corumbá, Abril *(MP)*; Río de Janeiro, 1940, Dupuy*(MP)*; M. Grosso, Janeiro 1955, Com. I. O. Cruz *(MNRJ)*; Itaí, VIII-1930, Cantoni *(MBA)*; Sao Paulo, Piracicaba, 6-V-62, Mesa *(FHC)*; Minas, Araxá, H.A. Torres *(MNRJ)*; Paraiba, Atafona Fox 2, 31-6-41, Santos De Lauro *(MNRJ,MZM)*; M. Grosso, R. 163 Gaucho, 22-I-72, Ronderos, Carbonell, Descamps *(MLP)*; M. Grosso, Corrego Boa Vista, 24-I-72, Ronderos, Carbonell, Descamps *(MLP)*; M. Grosso, Rondonopolis, R.364, 22-I-72, Ronderos, Carbonell, Descamps *(MLP)*; Reboncas, 9-26 *(ANSP)*; Nova Teutonia (27° 11' S 52° 29' W) 20-IV-1962, Plaumann, 300-500m. *(ANSP)*; Itali, Bruch *(ANSP)*; Ceará, Crato (serra de Araripe) 850m. May 1969, Alvarenga *(MZM)*;Santa Catarina, N. Teutonia (27° 11'S 52° 23'W), 9 May 1959, F. Plaumann *(MZM)*; Mato Grosso, Chavarantina (on Río das Mortes) 57° 27'W 64° 54'S, July 1962, M. Alvarenga & F.M. Oliveira *(MZM)*; M. Gerais, Santa Vitoria, February 1970 *(MZM)*; M. Grosso, Jaciara, November 1963, M. Alvarenga *(MZM)*; Bahía, 15-25 Nov. 1965, F.M. Oliveira *(MZM)*; Pará Cachimbo (54° 53', 8°i 56') Junio 1962, M. Alvarenga *(MZM)*; M. Gerais, Sao Romao, from cerrado and marsh, May 22-1941, J.B. Bailey *(MZM)*; M. Grosso, Porto Esperanza, Jan. 31-41, J.B. Bailey *(MZM)*.

Las siglas que acompañan a la mención del material examinado corresponden a las instituciones en los que se halla depositado: *ANSP*: Academy of Natural Sciences of Philadelphia (U.S.A.); *IEM*: Instituto de Entomología (Madrid); *IESM*: Instituto Entomológico San Miguel (Bs. Aires); *IML*: Instituto Miguel Lillo (Tucumán); *FHC*: Facultad de Humanidades y Ciencias, Universidad de la República (Uruguay); *MBA*: Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (Bs. Aires); *MLP*: Museo de La Plata; *MP:* Museum National d'Histoire Naturalle (Paris); *MZM*: Musem of Zoology, University of Michigan, Ann Arbor (U.S.A.); *MNRJ*): Museum Nacional (Río de Janeiro); *MZSP*: Museo de Zoología, Universidad de Sao Paulo.

Ommexecha macropterum Blanchard
(Figs. 1 a 9)

1836 – *Ommexecha macropterum:* Blanchard, Ann. Soc. Ent. France, *5*: 610; Serville, 1839, *Hist. Nat. Ins. Orthop.*: 699; Bolivar, 1899, *Rev. Chil. Hist. Nat., 3:* 55; Bruner, 1900, *2nd. Rep. Merch. Loc. Com. Bs. Aires:* 47; 1906, *Rev. Soc. Ent. Argentina, 10:* 165; *Mem. Inst. Oswaldo Cruz,* 53: 334; 1958, *INTA Inst. Patol. Veg. Publ. Tecn., 5:* 22; Liebermann y Pirán, Dir. *Gen. Lucha Langosta,* Montevideo: 9; Hayward, 1960, *Rev. Ind. Agric. Tucumán, 42* (1): 79; Eades, 1961, *Proc. Acad. Nat. Sci. Philad.,* 113: 170.

1839 – *Ommexecha macroptera:* Burmeister, *Handb. Entom.,2:* 655; Walker, 1870, *Cat. Derm. Salt. Brit. Mus., 4:* 719-797; Hebard, 1831, *Konowia, 10:* 271;Liebermann, 1945, *Acta Zool. Lillo ana, 3:* 237; Liebermann y Ruffinelli, *Rev. Asoc. Ing. Agron. Uruguay 74:* 17.

1884 – *Spathalium macropterum:* Bolivar, *An. Soc. Española Hist. Nat., 13:* 34.

1910 – *Ommexycha macropterum:* Kirby, *Syn. Cat. Orthopt., 3* (2): 297.

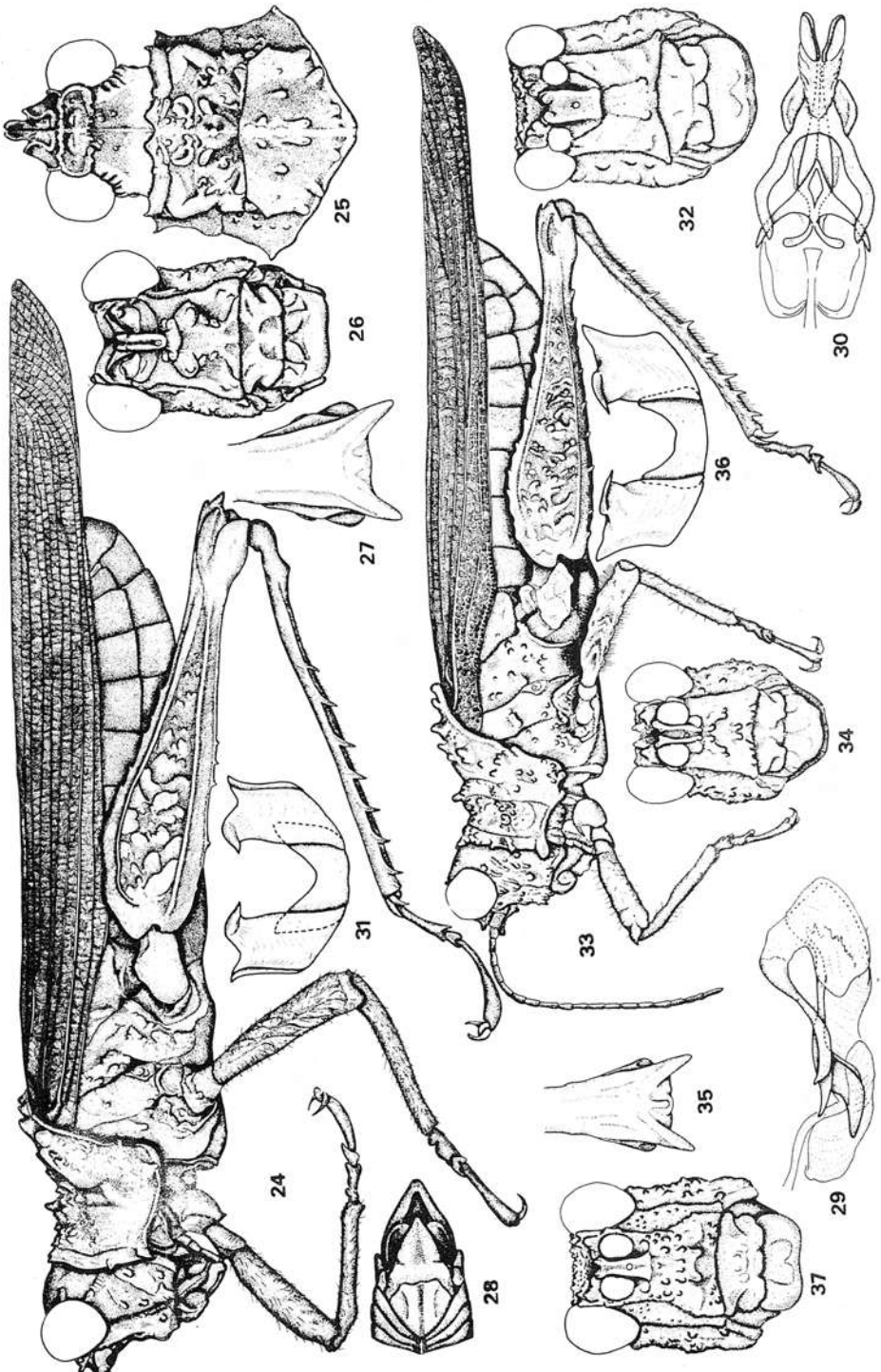
1899 – *Ommexecha caerulans:* Bolivar, *Rev. Chilena Hist. Nat. 3:* 6 – *(Nueva sinonimia).*

1910 – *Ommexycha caerulans:* Kirby, *Syn. Cat. Orthopt. 3* (2): 297.

Juntamente con *O. virens, O. macropterum* es la especie más mencionada, por haber sido las más abundantemente colectadas en sus respectivas áreas de distribución. La colaboración de sus alas, unida al desarrollo de las proyecciones geniculares de los fémures posteriores, la convierten en una especie de fácil reconocimiento.

Bolivar (1899) describe de Paraguay a *O. caerulans*, mencionando como caracteres diferenciales de la misma el poseer el tercer artejo tarsal de los fémures posteriores con igual longitud que el 1° y 2° reunidos y la ausencia de mancha oscura (negra) en la página interna de estos fémures. El estudio de la serie tipo (3♀♀ de Paraguay Central) nos ha demostrado que se trata de ejemplares de *O. macropterum*, siendo el único caracter que podría diferenciarla de ésta, la ausencia de la mancha negra en la página interna de los fémures posteriores, mancha que en realidad existe, solo que está parcialmente diluida, probablemente por tratarse de ejemplares recién mudados, ya que toda su coloración es muy clara; además, la referencia a la longitud relativa de los tarsitos de los fémures posteriores coincide totalmente con *macropterum* así como la coloración de las alas.

La caracterización de *O. macropterum* por lo tanto puede concretarse a la siguiente diagnosis: Insectos gráciles; cabeza con fastigio parcialmente declive tan largo como escapo y pedicelo en conjunto; ojos con su diámetro en vista dorsal más ancho que el espacio interocular en ambos sexos; en los machos, tan largos como las genas en vista frontal con prominencia lateral muy neta, superan ampliamente el ancho de la cabeza a



24 a 32, *Ommexecha brunneri* Bolivar [24 a 31, ♂ de Leonpampa, Perú (24, insecto adulto, vista lateral; 25, cabeza y pronoto, dorsal; 26, cabeza, frontal; 27, ápice del fémur posterior, dorsal; 28, segmentos genitales, dorsal; 29 y 30, cíngulo y endofalo, lateral y dorsal; 31, epifalo). 32, ♀ de Leonpampa, Perú, cabeza, frontal]. 33 a 37, *Ommexecha gracilis* Walker [33 a 36, ♂ de Igarape Gurupi; Brasil (33, insecto adulto, lateral; 34, cabeza, frontal; 35, ápice del fémur, posterior, dorsal) 37, ♀ de Igarapé Gurupí, Brasil, cabeza, frontal].

nivel de las genas; en las hembras con escasa prominencia, no superando el nivel de las genas en vista frontal. Pronoto estrecho, subparalelo a nivel de la flexión de los lóbulos laterales; estos sólo expandidos laterad en la metazona en su ángulo póstero-inferior. Tégmenes con ápice aguzado superando ampliamente el externo abdominal. Proyecciones geniculares de los fémures posteriores conspicuas pero no exageradamente prominentes, aguzadas.

Segmentos genitales del macho con epiprocto triangular, de ápice aguzado, 2 veces tan largo como su ancho máximo; placa subgenital levemente aguzada, puntiaguda. Placa subgenital en la hembra con guía del huevo superando levemente el borde caudal que es netamente aguzado.

Alas azules, celestes o incoloras; página interna de los fémures posteriores con una mancha rosada sub-basal que precede a una castaño oscura o negra.

Material Examinado

Holotipo♀ : Chiquitos, Bol., D'Orbigny, 1834 *(MP)*.

Argentina: *Salta:* Río Pescado, 13-10-72, Grisolía *(MLP)*; Tartagal (MBA); Caraparí, 22-1-45, Bridarolli *(IESM)*: Vespucio, 12-XI-65, Hepper *(MLP)*, Salta, Daguerre, 2-6-33 *(MBA)*; Orán, IX-62, Apostol *(MBA)*; Cafayate, 10-3-76, RB, EH, HR. Roberts (MLP). *Jujuy:* Ledesma, 28-I-58, Torres-Ferreyra *(MLP)*; Jujuy, IV-1911, Jorgensen *(ANSP)*.
Chaco: Resistencia, XI-35, Denier, *(MLP)*.

Bolivia: Santa Cruz, Buena Vista, III-71, Martinez *(IESM)*; Santa Cruz, III-1962, Apostol, 400 m, II-1962, Waltz *(ANSP)*; Santa Cruz, Nuflo de Chavez, Prov. Ascensión, 500 m, XI-1963, Waltz *(ANSP)*; Santa Cruz, Las Juntas, 250 m, Dec. 1913, Steinbach *(ANSP)*; Las Jungas, Chulumani, 19-25-Dec. 1955, L. E. Peña G. *(MZM)*; Rurrenabaque, 227 m "Low Tropic Región", 10-23-X-1956, L. E. Peña G. *(MZM)*; Cochabamba, El Palmar, 920 m, Forest Region 8-15-IX-1956, L. E. Peña G. *(MZM)*.

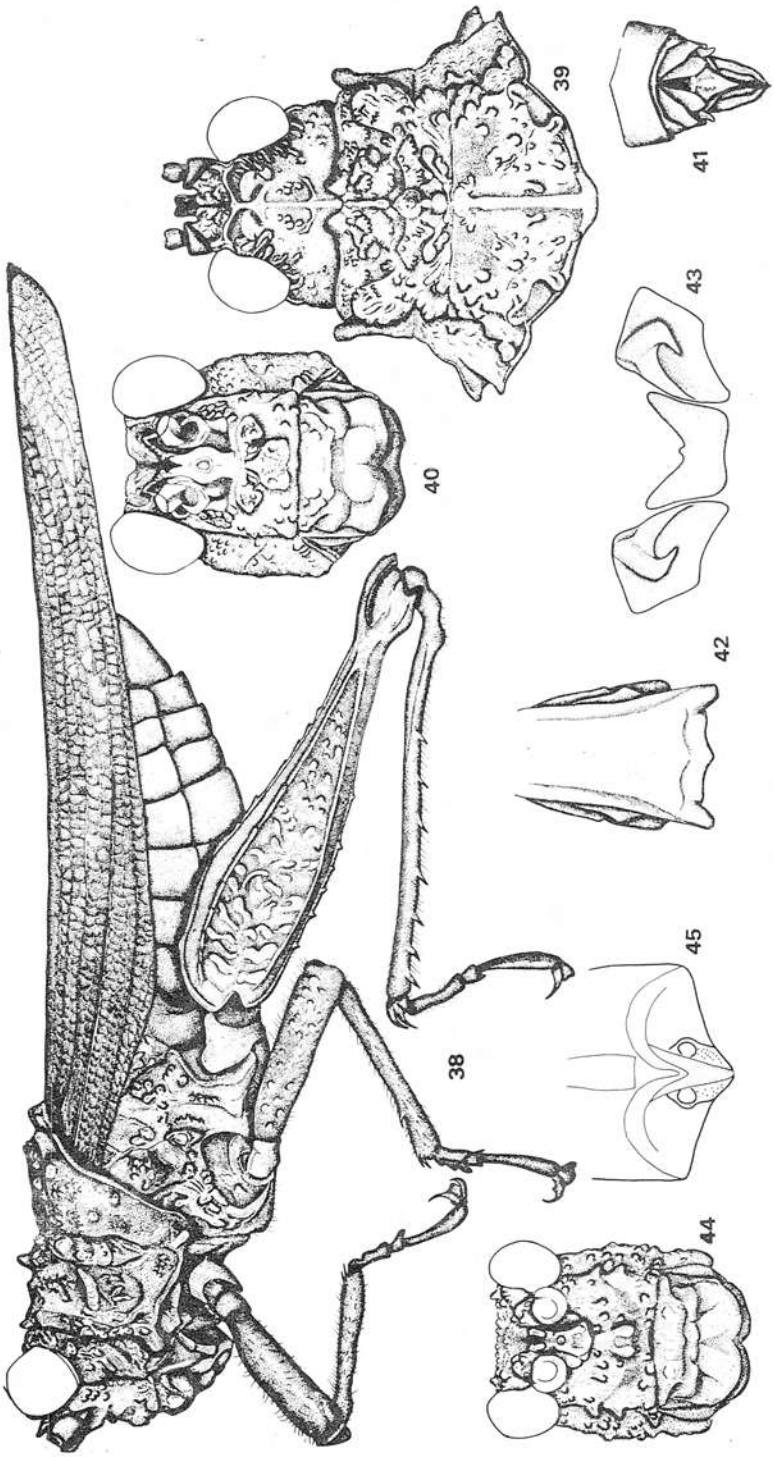
Brasil: M. G., Paracatu, VII-1960, Exp. Formosa *(MNRJ)*; M. Grosso, orillas río Araguaia, 10-VII-1953, C. S. Carbonell *(FHC)*; Pirapora, Carbalho 2-42 *(MNRJ)*; M. Grosso, Porto Jacaré, Río Xingú (12º S 53º 22'W) November 1961, M. Albarenga & Werner *(MZM)*.

Paraguay: *O. Caerulans* Bolivar, Paraguay Central (Holotipo♀ y 2 ♀♀ Paratipos).

Ommexecha brunneri Bolivar
(Figs. 24 a 31)

1884 – *Ommexecha brunneri* Bolivar, *An. Soc. Española Hist. Nat., 13:* 28; 1899, *Rev. Chilena Hist. Nat., 3:* 55; Giglio Tos, 1897, *Boll. Mus. Zool. Anat. Comp. Univ. Torino, 12* (302): 27; 1898, ibidem, *13* (311): 39; Bruner, 1910, *Hov. Soc. Ent. Rossice, 39:* 469; 1913, *Proc. U.S. Nat. Mus.*, 44: 179; Campos, 1923, *Rev. Coleg. Nac. Vicente Rocamora, 5:* 20; Liebermann, 1939, *Rev. Soc. Ent. Argentina, 10:* 165; 1955, *Mem. Inst. O. Cruz., 53:* 344; 1963, *Rev. Peruana Ent. Agric. 6* (1): 66; Roberts 1941, *Proc. Acad. Nat. Sci. Philad., 93:* 216; Eades, 1961, *Proc. Acad. Nat. Sci. Philad. 113:* 170; Randell, *Trans. Amer. Ent. Soc., 88:* 255.
1910 – *Ommexycha brunneri, Syn. Cat. Orthopt., 3* (2): 296.

La identidad de esta especie respecto de sus más próximas *(macropterum, gracilis y apolinari)* no ofrece dificultad, pese a la gran similitud aparente que presentan, siendo sus caracteres diferenciales respecto de las mismas los siguientes: Tegumento de cabeza y pronoto con tuberculado difuso. Cabeza con fastigio prominente, tan largo como escapo y pedicelo reunidos. Ojos, en los machos, prominentes laterad, superan lateralmente a las genas, con escasa a nula prominencia dorsal, tan anchos en vista dorsal como la mitad de la distancia interocular; pequeños en las hembras, con escasa prominencia tanto lateral como dorsal, con su ancho, en vista dorsal, menor que la mitad de la distancia interocular. Zona de flexión en los lóbulos laterales del pronoto con el disco paralelos; éstos con leve expansión lateral. Fémures posteriores con las proyecciones geniculares netas, divergentes y aguzadas.



Ommexecha giglio-tosi Bolivar. 38 a 43, ♂ de Vipos, Tucumán (38, insecto adulto, vista lateral; 39, cabeza y pronoto, dorsal; 40, cabeza, frontal; 41, segmentos genitales, dorsal; 42, ápice del fémur posterior; 43, epifalo). 44, ♀ de Vipos, Tucumán, cabeza, frontal.

Segmentos genitales del macho con epiprocto triangular, dos veces tan largo como su ancho máximo; plada subgenital puntiaguda y angosta, complejo fálico con las láminas laterales del epifalo subrectangulares y lophi perpendiculares.

Alas amarillas o amarillo verdoso, difusa próximo al borde caudal; página interna de los fémures posteriores como en *macropterum.*

Material examinado:

Hololectotipo ♂, alolectotipo ♀, paralectotipos, 1 ♂ 1♀: Perú 10347 **(Museo de Viena)**

Bolivia: Colorados, N. Yungas, X–1968, Martinez *(MLP);* Yacuiba *(MBA);* Pcia. Sara, Nueva Maka, II–1950, Martinez *(IESM);* Chuquisaca, alrededores de Sucre, 15-VI-48, C. S. Carbonell *(FHC).*

Perú: Leonpampa, 110 km Huánuco, Huánaco Prov., Tropical Jungle, December 1937, F. Waytkowsky *(ANSP);* Rio Pichites, Monte Alegre, Tessman *(MP);* Huánaco, Triego María, 10-VII-1948, C. S. Carbonell (FHC); Yurimaguas, Huallanga River, IV-6-1920, H. S. Parish (ANSP); Puerto Jesup, II-1930, M. A. Carriker *(ANSP);* Puerto 28 de Julio, Rio Pichis, II-1930, M. A. Carriker *(ANSP);* Iberia, Madre de Dios Ma. 1-1947, 500 ft.; J. C. Pallister *(ANSP);* Chanchamayo 1000 m, III-1910 (ANSP); Utcuyacu, Tarnia, Junín, 1600-1300 m, Feb. 14-1948, F. Woytkowsky *(MZM);* Contamana, So. An., 1920, W. R. Allen *(MZM);* 11° 8'S, 78° 17'W Greenw, 1000 m, N. Iconnicoff. 22-12-01 (MZM); Iquitos, 21 Nov. 1963, L. E. Licht (MZM); Cuzco, Quincemil, 700 m. 14-31 Aug. 1962, L. E. Peña G. *(MZM);* ? Cuzco, Conomayo, 4-10 Sept. 1962, L. E. Peña G. *(MZM).*

Ecuador: Lago Agrio, Napo 270 m, IV-76, Martinez *(IESM);* Napo-Pastasa, Santa Cecilia (76° 58'W 0° 2'N) on Rio Aguarico, 8-14 Jul. 6; Loja, Cumbaratza, NE of Zamora, 7 April 1965, L. E. Peña G.; Loja, Yantzaza (W. Zamora) 30 March 1965, L. E. Peña G. *(MZM).*

Ommexecha giglio-tosi Bolivar
(Figs. 38 a 43)

1899 – *Ommexecha giglio-tosi* Bolivar, *Rev. Chilena Hist. Nat., 3:* 55; Bruner, *Ann. Carnegie Mus., 8:* 460; Rehn, 1918, *Proc. Acad. Nat. Sci. Philad., 65:* 328; 1916, *Trans. Amer. Ent. Soc., 42:* 282; 1918, *Proc. Acad. Nat. Sci. Philad.:* 169; Hebard, 1923, *Trans. Amer. Ent. Soc., 49:* 218 (error de identificación); 1931, *Konowia, 10:* 271; Liebermann, 1939, *Rev. Soc. Ent Argentina, 10:* 164.

1910 – *Ommexycha giglio-tosi:* Kirby, *Syn. Cat. Orthopt., 3* (2): 297.

Esta especie es descripta por Bolivar en base a ejemplares de Argentina (Aguairenda) y Bolivia (Caiza y San Francisco) y referida a *O. macropterum* por Hebard (1931), en base a paratipos depositados en la Academia de Ciencias Naturales de Filadelfia, de igual procedencia. El estudio de los tipos depositados en el Instituto Español de Entomología y los paratipos mencionados por Hebard (op. cit.), nos permiten confirmar la bondad de esta especie, así como también referir los ejemplares rotulados por Bolivar como *O. brunneri,* con igual procedencia, a esta especie.

Esta especie es próxima a *O. virens,* de la que difiere por su mayor tamaño en ambos sexos, además de los siguientes caracteres: Insectos robustos, macrópteros, los tégmenes superan ampliamente el ápice del abdomen. Tegumento en cabeza y tórax densamente tuberculado; fastigio levemente declive, con la excavación mediana longitudinal insinuándose levemente en la costa frontal. Ojos, en ambos sexos, si bien prominentes laterad, no superando el nivel de las genas en vista frontal; éstos, en los machos, más anchos que la mitad del ancho del espacio interocular; iguales en las hembras. Proyecciones geniculares de los fémures posteriores escasamente desarrolladas, romas. Segmentos genitales del macho con epiprocto triangular, tan largo como su ancho máximo pero de ápice aguzado. Epifalo semejante a *virens,* al igual que la placa subgenital de la hembra. Coloración de las alas y página interna de los fémures posteriores como en *brumeri.*

Material examinado:

Holotipo ♂, alotipo ♀, paratipos 3 ♀♀, 2 ♂♂, Aguairenda *(IEE)*; 1 ♀ Caiza *(IEE)*.

Argentina: *Jujuy:* Jujuy, 13-VII-1924 *(MLP)*; Ledesma, 21-I-56, Torres-Ferreyra *(MLP)*; Rio Yala, 5-V-68, Bianchini *(MLP)*; *Salta:* La Candelaria, 15-5-65, A. Mesa, R. Sandulsky *(FHC)*; Rio Tartagal, XI-65, Hopper *(MLP)*; Pocitos, III-62, Martinez *(MLP)*; Orán *(MBA)*. Tucumán, Raco, Bosq *(MLP)*; El Tajamar, Burruyacu, 8-VI-54, Maldonado *(MLP)*; Vipos, IV-60, Hopper *(MLP)*; Qa de los Sosa, 11-IX-60, Gaillordo *(MBA)*; San Pedro de Colalao, 5-X-55, H.E. Millivan, *(ANSP)*; *La Rioja:* La Rioja *(MBA)*; *Catamarca:* Catamarca *(MBA)*; Los Alamitos, II-51, Kormilev (IML).

Bolivia: Caiza; San Francisco; Aguairenda *(ANSP, IEE, MLP)* Holotipo, Alotipo y Paratipos.

Ommexecha apolinari Hebard
(Figs. 10 a 17)

1923 – Hebard, *Trans. Amer. Ent. Soc., 49:* 218.

Salvo la descripción original, no existe hasta el momento ninguna otra mención a esta especie. La descripción de Hebard coincide con los materiales por nosotros estudiados, los que incluyen a los de la serie tipo y nuevas localidades, todos ellos de Colombia.

Si bien Hebard la ubica próxima a *giglio-tosi*, es más correcto referirla al grupo *macropterum, brunneri, gracilis.* por su tuberculado menos denso en el tegumento de cabeza y tórax; forma del epifalo en los machos y forma de la placa subgenital en las hembras. Los caracteres más distintivos respecto de sus más próximas son los siguientes: tégmenes si bien largos y superando el ápice del abdomen, con el extremo redondeado; fastigio marcadamente declive; proyecciones geniculares de los fémures posteriores, si bien evidentes, cortas; epiprocto en los machos triangular, levemente más largo que su ancho máximo. Alas amarillo verdoso tenue.

Material examinado:

Holotipo ♂: Cordillera la Quinta, Colombia, A. María, XII–1916; alotipo ♀: ibidem; paratipos: 1 ♂ y 1 ♀, Susumuco, A. María, XII–1916 *(ANSP)*.

Colombia: Medina, XII–1930; A. María *(ANSP)*; Muzo, Boyacá, A. María *(ANSP)*; Meta, Villavicencio, VII–18–1938, F. W. Furry (MZM); Darien, 33–96 *(MP)*; Putumayo, bord Río Mocoa entre Villa Garzón et Puerto Limón, 300 m, 14–XI–68, M. Descamps *(MP)*.

Ommexecha gracilis Walker
(Figs. 33 a 37)

1870 - *Ommexecha gracilis* Walker, *Cat. Derm. Salt.* (Brit. Mus.) *4:* 798.

1910 - *Ommexycha gracilis* Kirby, *Syn. Cat. Orthopt.*, 3 (2): 297.

1959 - *Ommexecha walkeri* Kevan, *Publ. Cult. Comp. Diamantes Angola*, 43: 161 *(Nueva Sinonimia)*.

Especie próxima a *O. macropterum*, sólo mencionada en su descripción original (Walker, 1870), de la que se diferencia por los siguientes caracteres: tegumento de cabeza y tórax con tubérculos netos, abundantes. Ojos en ambos sexos no superando el borde de las genas en vista dorsal, mayor que la mitad del espacio interocular; patas anteriores y medias con pubescencia densa en fémures y tibias. Alas amarillo verdoso diluido, casi incoloras.

Material examinado:

Brasil: Igarapé Gurupí, Uma aldea Aranza, Ma., 50 km E Canindé, 3–V–63, Malkin, Col *(MZSP)*; Río Negro, Amazonas, 13–II–72, Exp. Amazonas *(MZSP)*; Peixe Boi, E of Pará, H. B. Merriel, Nov. Dec. 1907 *(MZM)*; Igrapé Assu, Sta. of Pará, H. S. Parish, *(ANSP)* Acre, Cruzeiro do Sul, Feb. 1963, Alvarenga *(MZM)*; Manaus, Amazonia, Parkois 1941 *(MNRJ)*; Pará, Río Trombeta, IX–1965 Exp. Dep. Zool. *(MZSP)*; Alegre, 15 km Marapanim, 8–11–IX–1965, Exp. Dep. Zool. *(MZSP)*.

Guayana Francesa: Charvein, Benoit, 1916 (MP).

Guayana Holandesa: Surinam, Langaman Kondre, VIII–1965, R. Malkin *(MZSP)*.

Venezuela: Anzoategui, Moitaca, 13–IX–40 (MZM); Bolívar, Puerto Mojados, Desembocadura Río Caura en Orinoco, 5–14–1957, P. San Martín *(FHC)*.

Observaciones. Las especies que integran el género *Ommexecha* presentan una gran homogeneidad. Este género es fileticamente muy próximo a *Pachyossa* Rehn y *Descampsacris* Ronderos, de los que difiere principalmente por ser insectos más gráciles, aún las formas braquípteras; poseen los fémures posteriores más delgados; fastigio prominente declive, a lo que debe agregarse la estructura del ducto de la espermateca en las hembras y forma del epifalo en los machos.

Pueden ser integradas dos grupos de especies: uno constituido por *virens* y *giglio-tosi* y el restante por *macropterum, brunneri, apolinari y gracilis*. El carácter más sobresaliente para la separación de ambos lo constituye el desarrollo de las proyecciones geniculares, reducidas a muñones en el primero y proyectadas caudad con desarrollo variable, pero conspicuas en el segundo y la forma de las láminas laterales del epifalo en los machos.

La caracterización de estos taxa es dificultosa por su gran homogeneidad morfológica y cromática, lográndose su individualización sin grandes inconvenientes si se tienen en cuenta los caracteres mencionados arriba, el desarrollo lateral de los lóbulos laterales del pronoto, tamaño relativo de los oios, espacio interocular y coloración de las alas.

El complejo fálico en los machos no aporta caracteres específicos, salvo los mencionados para el epifalo; igual comentario merece la genitalia femenina y sus anexos. La coloración de las alas, en el caso particular de *gracilis* y *macropterum* es su carácter decisivo de gran valor diagnóstico.

Distribución geográfica

El límite Septentrional de dispersión de este género está entre los paralelos 30° y 35° S, presentando su mayor diversidad al Norte del Trópico de Capricornio.

Aún en las zonas tropicales sus distintas especies están asociadas a sabanas, matorrales, praderas y campos de cerrado con marcada insolación y caracterizados por presentar terrenos arenosos o arcillosos con bajo tenor de humedad.

En el total de las especies conocidas es *O. virens* la que presenta más amplia distribución, ocupando zonas llamadas por Hueck y Siebert (2) "Sabanas; Estepas arbustivas y graminosas, semidesiertos y desiertos" desde los 2° de la latitud Sur hasta los 35° S insinuándose al Oeste hasta los 64° W en el Sur de Brasil y Bolivia, Paraguay y Norte de Argentina. En todos los casos coincide con bordes de matorrales, campos de cerrado y sabanas asociada permanentemente a *Acanthopermus australe*. Se la ha mencionado (Blanchard, Liebermann) en plantaciones de tabaco, pero en ningún caso se han reportado daños en estos cultivos producidos por esta especie.

O. giglio-tosi, próxima a *virens*, ocupa la fracción oriental de los Andes en Argentina (La Rioja, Catamarca, Salta, Jujuy, Chaco y Formosa), vinculada a la "Estepa arbustiva de Monte", al "Bosque seco del Chaco Central" y a la "Transición del Bosque seco de los espinales a la Vegetación del Monte", formaciones estas que se insinúan en la región central de Bolivia (Santa Cruz) donde habita también *virens*.

(2) – Hueck, K. y P. Seibert 1972. Vegetationskarte von Südamerika, Gustav Fischer Veriag Ed Stuttgart, 70 pág., 1 map.

Casi coincidiendo con la distribución de las dos primeras, en la región central del continente se halla *O. macropterum,* la que además de las formaciones mencionadas ocupa en forma notoria los "Campos de Cerrado" penetrando hacia el SE en lo que se ha dado en llamar las "Praderas y Matorral de las Pampas Onduladas" en el Sur de Brasil y Noroeste de Uruguay.

O. brunneri ofrece un panorama semejante en cuanto a sustrato, pero limitando su ámbito de dispersión a una franja al E de los Andes entre los 0º y 20º S, llegando a altitudes de hasta 2000 m en el "Bosque de Ceja" y en la llamada "Hyalea próxima a los Andes". En los llanos de Colombia, al Este de la Cordillera Principal se encuentra *O. apolinari* ocupando la llamada "Hyalea Occidental" a altitudes de 50 a 200 m con alto régimen pluvial (2400 a 4000 mm) caracterizada por una pluviselva sobre suelos libres de inundaciones.

Finalmente *O. gracilis* ocupa el sector Nororiental de Sudamérica entre los ríos Orinoco y Amazonas en la "Pluviselva del Amazonas y Orinoco", a lo largo de los rios y en zonas abiertas con vegetación baja y en la Caatinga.

Es evidente que el genocentro de *Ommexecha* está ubicado en la zona central de Sudamérica, con características climáticas y fitogeográficas comunes a la familia, sector en el que coinciden *macropterum y virens,* probablemente las dos líneas de especiación primaria de un ancestro común.

A la inversa de muchos otros grupos de Acridiomorpha, *Ommexecha* y los restantes integrantes de la subfamilia que han colonizado el Centro y Norte del Continente, lo han hecho en sentido Sur-Norte, y en nuestro caso particular a partir de *macropterum* por el borde Oriental de los Andes, con la secuencia *bruneri, apolinari,* mientras *gracilis* divergió conjuntamente con *brunneri* colonizado al sector hoy por ella ocupado, mientras *virens* daba origen a *giglio-tosi.*

Se carecen de datos respecto a las zonas no marcadas en el mapa respectivo, pero es de suponer que *macropterum* o *gracilis* o ambas, llenen esos claros pudiendo tal vez *apolinari* insinuarse hascia el oriente. La no presencia de representantes del género en Argentina, al Sur del área demarcada para *virens, macropterum* y *giglio-tosi* puede asegurarse, al igual que en Chile, no así en los sectores vacíos que delimitan *virens, brunneri, apolinari* y *macropterum* en el sector Central de la Amazonia.

ABSTRACT

DISTRIBUTIONAL HISTORY OF SOME NORTH AMERICAN FLIGHTLESS GRASSHOPPERS OF THE GENUS *MELANOPLUS*

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Melanoplus scudderi is a brachypterous acridid presently recognized as breaking into three ill-defined subspecies. A study of the concealed male genitalia has revealed a multitude of different populations. One assemblage of these populations occurs, with the exception of the southeastern coastal plain, over most of the eastern United States as far west as a line drawn from southeastern North Dakota to Central Louisiana. Within this area two gradients exist. A stepped east-west gradient running along a line through central Illinois and the east side of the Mississippi floodway joins the two gradients.

The following hypotheses are advanced to account for the present distribution of the forms of this complex. Prior to the Pleistocene glaciers a single generalized species occupied eastern United States. Ebb and flow of the ice divided this population into several parts. The glacial Mississippi and Ohio rivers served as barriers separating three populations. One of these was located on the Salem Plateau in the Ozarks, a second was isolated on Crowley's Ridge in northeastern Arkansas, and a third existed south of the glacial border to the east of the Mississippi floodway. A fourth population was isolated on an offshore island or islands in southern Alabama. The small populations in southern Alabama and on Crowley's Ridge differentiated the most and gave rise to the extremes found in each of the two gradients. The other two populations, both large, differentiated to a lesser degree; that occurring in the Ozarks shows the greatest change. Retreat of the glaciers, with subsequent occupation by the grasshoppers of new habitat as it became available, has resulted in the present distributions.

ESTUDIO DE LAS MANDIBULAS Y ANALISIS DE LAS HECES EN 15 ESPECIES DE TUCURAS COLECTADAS EN ALFALFARES DE CORDOBA, (REP. ARG.) (Orthoptera, Acrididae)

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INTRODUCCION

Así como es abundante la bibliografía acerca de los hábitos alimentarios de Acridoideos de otros países especialmente de la región Holarctica, muy poco es lo que se conoce sobre especies de la región Neotropical y menos aún las correspondientes a nuestro país. Carbonell (1959) analiza las mandíbulas de *Marellia remipes;* Liebermann (1968) estudia las mandíbulas en tucuras de la subfamilia Chilacridinae; pero en un trabajo reciente de Gangwere y Ronderos (1976) donde se hace un estudio preliminar de la selección de alimento en Acridoideos de Argentina. Estos autores realizan observaciones de campo y analizan las mandíbulas y contenido de las heces de 70 especies de Acridoidea pertenecientes a 9 familias y subfamilias.

Diversos insectos, entre los que se pueden citar pulgones, isocas, chinches, oruga grasienta, etc. inciden en forma negativa en la productividad de alfalfa. Su acción destructiva se ve favorecida por otros factores como sequía, sobrepastoreo, invasión de malezas, etc. Las tucuras intervienen en forma directa en la degradación de esta forrajera por tratarse de insectos masticadores, fitófagos, tanto en estado ninfal como imaginal.

En el presente trabajo se ha llevado a cabo un relevamiento acridiológico en los alfalfares de la Estación Agropecuaria Manfredi (INTA), Córdoba, República Argentina, durante la 2ª. quincena de febrero, marzo y abril de 1976, con el objeto de determinar las especies que en ellos habitan. Además se estudiaron las mandíbulas en cada una de las especies colectadas y se analizaron las heces con el fin de establecer cuales de aquéllas incluyen en su dieta habitual alfalfa, otras dicotiledóneas o gramíneas, estableciendo de este modo el verdadero papel que juegan cada una de ellas en los alfalfares.

AGRADECIMIENTOS

Deseo expresar mi reconocimiento a la Dra. Mireya M. de Brewer por las importantes sugerencias aportadas. Al Dr. Ricardo Ronderos por la lectura de los originales y clasificación del material. Al Ing. Agr. Jorge Báez, Director de la Estación Experimental del INTA de Manfredi por haber permitido la recolección del material en los alfalfares experimentales. Al Ing. Armando Hunziker y personal del Dpto. de Botánica que determinaron el material. A la Dra. Alicia de Solís por su asesoramiento en la parte de Morfología Vegetal.

MATERIAL Y METODO

I. Campo.

En la recolección del material se usó red de arrastre, realizando 20 golpes por vuelta, en los bordes y centro del alfalfar, generalmente en horas del medio día. También se llevó a cabo la recolección manual. En todos los casos sólo se colectaron imagos. Las ninfas no pudieron ser estudiadas debido a la dificultad, por falta de bibliografía, para reconocer las diferentes especies. Los ejemplares se colocaron por separado en un tubo de ensayo con tapón de algodón, agregando los datos corrientes y lugar de recolección en el alfalfar.

II. Laboratorio.

El material así acondicionado permaneció 24 hs. tiempo suficiente para la defecación. Previa extracción de las mandíbulas, el material fue montado y etiquetado. Las mandíbulas se conservaron, para su posterior estudio, en pequeños tubos que se colocaron debajo de las etiquetas de las especies correspondientes. Las heces se guardaron por separado, en sobres de papel vegetal.

Con el objeto de individualizar en las heces la presencia de alfalfa se hicieron preparados de epidermis de diferentes partes del vegetal. El resto de los vegetales encontrados se clasificó como "otras dicotiledóneas o gramíneas" sin llegar a determinar la especie. Al tratar *Dichroplus pratensis* Bruner no se llevó a cabo el análisis de las heces por el escaso número de que se dispuso. Se trata de una especie que aparece raramente en los alfalfares.

Para la clasificación de las mandíbulas se siguió el trabajo de Gangwere (1965) y para el de las heces, el trabajo del mismo autor (1962).

Los dibujos fueron realizados bajo lupa binocular estereoscópica provista con ocular reticulado.

COROGRAFIA DEL AREA ESTUDIADA

Según Brewer y Varas (1973), la Estación Agropecuaria Manfredi está ubicada a 1500 m al S.E. del pueblo Manfredi, Pedanía Impira, Dpto. Río Segundo, a 31º 49'12" de latitud S; 63º 46' longitud O y a una altura de 292 m sobre el nivel del mar.

Ocupa el sector central de la zona semiárida, dentro de la isoieta de 700 mm, con un régimen de precipitaciones primaveroestival de 550 mm, entre octubre y marzo. Son frecuentes los vientos de llanura, en dirección N–S, en ambos sentidos.

El terreno es llano, de suelo castaño, profundo, sin capas impermeables que dificulten el paso de raíces o del agua. Loes pampeano franco-arenoso fino de perfil AC. El horizonte A es pardo en seco y pardo oscuro en húmedo. Presenta el 25 o/o de materia orgánica y un pH de 6,5.

Flora

Las plantas que con mayor frecuencia crecen en los alfalfares experimentales que sirvieron de estudio son:

Gramíneas:

Echinochloa colonum (L.) Link
Eragrostis virescens Presl.
Eleusine indica (L.) Gaertn.
Eragrostis cilianensis (All.) Vign. Lutati
Bromus unioloides H.B.K.
Digitaria sanguinalis (L.) Scop..

Compuestas:

Toraxacum sp.

Quenopodiáceas:

Kochia scoparia (L.) Schr.
Chenopodium sp.
Chenopodium album L.

Amarantáceas:

Amaranthus quitensis H.B.K.

Especies de tucuras colectadas en los alfalfares

Romaleidae:

Chromacris speciosa (Thunb.)
Zoniopoda omnicolor (Blanch.)

Acrididae:
Gomphocerinae:

Orphulella sp.
Rhammatocerus pictus (Bruner)
Staurorhectus longicornis G. Tos
Allotruxalis strigata (Bruner)
Dichromorpha australis (Bruner)
Scyllinops bruneri (Rehn)
Euplectrotettix conspersus Bruner

Melanoplinae:

Dichroplus elongatus G. Tos
Dichroplus exilis G. Tos
Dichroplus punctulatus (Thunb.)
Dichroplus conspersus Bruner
Dichroplus vittatus Bruner
Dichroplus pratensis Bruner

RESULTADOS

Siguiendo la metodología antes expuesta se investigó el tipo de mandíbulas, heces y alimento ingerido en 15 especies correspondientes a 2 familias.

Romaleidae:

Esta familia estuvo representada por *Chromacris speciosa* (Thunb.) y *Zoniopoda omnicolor* (Blanch.), abundantes durante toda la época de estudio. Vuelan muy poco y generalmente se las encuentra en aquellas partes del alfalfar libres de malezas. Ambas presentaron mandíbulas de tipo Fb. adaptadas para ingerir dicotiledóneas y las heces de tipo IC asimétricas, compuestas de fragmentos no alineados de dicotiledóneas (Figs. 1 y 4). En cuanto al contenido de éstas *Z. omnicolor* presentó en el 82,13 o/o de las heces sólo restos de alfalfa, en el 10,71 o/o había alfalfa y gramíneas y en el 7,14 o/o otras dicotiledóneas, mientras que en *C. speciosa* en el 95,88 o/o de las heces había restos de alfalfa y tan sólo en el 4,11o /o restos de otras dicotiledóneas; no se encontró gramíneas.

C. speciosa frecuenta solanáceas; en estado ninfal tiende a ser gregaria y gran cantidad de individuos se encuentran frecuentemente posados sobre *Cestrum parqui.* Liebermann (1954, 1958, 1966) la cita como causando daños en cultivos de tomate, tabaco y papa, como así también en malezas, especialmente *Trichloris crinita.*

CUADRO COMPARATIVO DE TIPOS DE MANDIBULAS, TIPOS DE HECES Y CONTENIDO DE LAS MISMAS EN 15 ESPECIES DE TUCURAS COLECTADAS EN ALFALFA

			Porcentaje de heces según su contenido					
	Mand.	Heces	Alfalfa	Alf. y gram.	Gram.	Alf. y otras dicot.	Gram. y otras Otras dicot.	Gram. y otras dicot.
Zoniopoda omnicolor (Blanch.)	Fb.	IC	82,13	10,71	–	–	7,14	–
Chromacris speciosa (Thunb.)	Fb.	IC	95,88	–	–	–	4,11	–
Rhammatocerus pictus (Bruner)	Gm.	IA	–	–	100	–	–	–
Staurorhectus longicornis G. Tos	Gm.	IA	–	–	100	–	–	–
Orphulella sp.	Gm.	IA	–	1,40	98,59	–	–	–
Allotruxalis strigata (Bruner)	Gm.	IA	–	–	100	–	–	–
Dichromorpha australis Bruner	Gm.	IA	–	–	100	–	–	–
Scyllinops bruneri (Rehn)	Gm.	IA	–	–	100	–	–	–
Euplectrotettix conspersus Bruner	Gm.	IA	–	–	100	–	–	–
Dichroplus elongatus G. Tos	Fb., Hb.	IB	22,58	35,48	38,7	–	–	3,24
Dichroplus exilis G. Tos	Fb., Hb.	IB, IC	87,5	2,5	–	10	–	–
Dichroplus punctulatus (Thunb.)	Fb., Hb.	IB, IC	27,27	4,54	22,72	9,09	18,18	18,18
Dichroplus conspersus Bruner	Hb.	IB, IC	61,11	11,11	22,22	5,55	–	–
Dichroplus vittatus Bruner	Fb., Hb.	IB	20,83	41,60	29,16	8,33	–	–
Dichroplus pratensis Bruner	Hb.	IB	–	–	–	–	–	–

Acrididae: Gromphocerinae.

Subfamilia representada en los alfalfares estudiados por 7 especies, las que presentaron en todos los casos mandíbulas de tipo Gm adaptadas para ingerir monocotiledóneas y heces IA, alineadas (Figs. 2 y 4).

Se trata de especies altamente graminívoras. *Rhammatocerus pictus* (Bruner) presentó en el 100 o/o de las heces analizadas sólo restos de gramíneas. Posee fototaxismo positivo; en la Ciudad de Córdoba es frecuente observar, en las noches de verano, gran cantidad de ejemplares en los focos de luz artificial. Según Liebermann y Schiuma (1946) produce daños en las pasturas naturales e invade las plantas cultivadas. Liebermann (1968) la encontró en grado de plaga en los Departamentos Marcos Juárez y Unión, en Córdoba, donde constituía el 75 a 80 o/o de la población total, especialmente presente en los alfalfares en decadencia.

Staurorhectus longicornis G. Tos frecuenta gramíneas en campos naturales. En los alfalfares se localiza en los bordes, estableciéndose en el centro únicamente cuando está invadido de malezas. Liebermann (1968) la considera una especie graminívora y gramincola. En el 100 o/o de las heces se encontró únicamente restos de gramíneas.

Orphulella sp. y *Allotruxalis strigata* (Bruner) son dos especies frecuentes en el alfalfar y como en el caso anterior siempre se las recoge en los bordes. Según Gangwere y Ronderos (1976) *A. strigata* parece ser altamente selectiva en su alimentación graminívora pues el contenido de sus heces reveló sólo unas pocas especies de gramíneas, no así *Orphulella* sp. que se muestra poco selectiva en la ingestión de gramíneas. El análisis de las heces de esta última reveló que en el 98,59 o/o había gramíneas y en el 1,40 o/o restos de gramíneas y alfalfa, en cambio *A. strigata* presentó en el 100 o/o de las heces sólo gramíneas.

Las restantes especies de esta subfamilia, *Dichromorpha australis* Bruner, *Scyllinops bruneri* (Rehn) y *Euplectrotettix conspersus* Bruner se encontraron en escaso número en el alfalfar y en el 100 o/o de sus heces había gramíneas. Gangwere y Ronderos (1976) consideran a *S. bruneri* económicamente importante en la zona Atlántica de la Provincia de Buenos Aires y Uruguay. Silveira Guido et al. (1958) la mantuvieron en cautividad sobre pastos delicados, especialmente *Digitaria* y *Paspalum*. Liebermann recogió *E. conspersus* sobre *Stipa* y otros pastos naturales; también la observó dañando *Muhlenbergia* y *Padophorum* dos pastos que son vitales, según estos autores, para la ganadería.

Acrididae, Melanoplinae:

Subfamilia de distribución amplia, representada en los alfalfares estudiados por 6 especies del género *Dichroplus* Stal. *D. pratensis* Bruner en escaso número, no así *D. elongatus* G. Tos, *D. exilis* G. Tos y *D. punctulatus* (Thunb.) que se presentan en forma abundante. En grado decreciente le siguen *D. conspersus* Bruner y *D. vittatus* Bruner. Tanto *D. punctulatus* como *D. conspersus* prefieren los bordes del alfalfar, mientras que las restantes especies frecuentan las partes libres de malezas.

El estudio de las mandíbulas en *D. elongatus* puso de manifiesto que son de tipo Fb o su modificación Hb. adaptada para ingerir tanto mono como dicotiledóneas. Las heces de tipo IB, semialineadas con restos de gramíneas y dicotiledóneas (Figs. 3 y 4) y su contenido representado por: en el 22,58 o/o había alfalfa; en el 35,48 o/o alfalfa y gramíneas; en el 38,7 o/o gramíneas y en el 3,24 o/o gramíneas y otras dicotiledóneas. Comúnmente se la designa con el nombre de "tucura alargada" o "tucura de los alfalfares". Liebermann (1949) la encontró en Calingasta (San Juan); el mismo autor (1967) la cita para olivo, zanahoria, papa, sandía, melón y tomate; Ronderos, Carbonell y Mesa (1968) la encontraron en cultivos de alfalfa y maíz; Orrego Aravena (1969) la considera común en alfalfares y praderas y que en el año 1960 en Huinca Renancó, Córdoba, constituía numéricamente el 80 o/o de las tucuras existentes en la región.

D. exilis, como la especie anterior presentó mandíbulas Fb o su modificación Hb y las heces IB o IC. En el 87,5 o/o de las heces analizadas había tan sólo restos de alfalfa; en el 10 o/o alfalfa y otra dicotiledóneas y el 2,5 o/o restante correspondió a gramíneas y alfalfa. Aparte de esta forrajera se la observó sobre soja y maní en Manfredi y en sorgo en Río Cuarto, Córdoba. Liebermann (1958) la menciona atacando un cultivo de batata *(Ipomea batata)*.

D. punctulatus ampliamente distribuída en Sudamérica, prefiere dietas variadas. En el 27,27 o/o de las heces había alfalfa; en el 22,72 o/o gramíneas; en el 18,18 o/o gramíneas y otras dicotiledóneas; en el 18,18 o/o otras dicotiledóneas; en el 9,09 o/o alfalfa y otras dicotiledóneas y el 4,54 o/o representado por alfalfa y gramíneas. Las mandíbulas fueron de tipo Fb o Hb y las heces IB o IC.

D. conspersus aparece al final del verano y se mantiene hasta entrado bastante el otoño. No es muy abundante y como la especie anterior frecuenta los bordes del cultivo. Presentó mandíbulas Hb y la forma de las heces correspondió al tipo IB o IC. En cuanto al contenido de éstas últimas, en el 61,11 o/o había sólo alfalfa; en el 11,11 o/o alfalfa y gramíneas; en el 22,22 o/o gramíneas y en el 5,55 o/o alfalfa y otras dicotiledóneas. Liebermann (1967) la considera plaga en Uruguay y común en las pasturas verdes del litoral.

En *D. vittatus* las mandíbulas fueron de tipo Fb o Hb y las heces de tipo IB. El análisis de éstas reveló que en un 20,83 o/o había alfalfa; en el 41,60 o/o alfalfa y gramíneas; en el 29,16 o/o gramíneas y en el 8,33 o/o alfalfa y otras dicotiledóneas. Liebermann (1958) la observó devorando hojas y frutos de olivo, jarilla y gramíneas.

D. pratensis es poco frecuente en los alfalfares de Manfredi lo que impidió disponer de un número suficiente de deyecciones para someterlas a análisis. Las mandíbulas fueron de tipo Hb y las heces de tipo IB. Liebermann (1949) la considera plaga en los maizales de San Luis y abundante sobre los pastizales de Buenos Aires y La Pampa.

CONCLUSIONES

El análisis de las mandíbulas y heces en las 15 especies de tucuras recogidas en alfalfares experimenales de Manfredi, Córdoba, permitió arribar a las siguientes conclusiones:

1 — En los alfalfares de Manfredi fueron colectadas dentro de la familia Romaleidae las siguientes especies: *Zoniopoda omnicolor* (Blanch.) y *Chromacris speciosa* (Thunb.).

2 — De la familia Acrididae, Gomphocerinae, fueron colectadas: *Rhammatocerus pictus* (Bruner), *Staurorhectus longicornis* G. Tos, *Orphulella* sp., *Allotruxalis strigata* (Bruner), *Dichromorpha australis* (Bruner), *Scyllinops bruneri* (Rehn), *Euplectrotettix conspersus* Bruner y los siguientes Melanoplinae: *Dichroplus elongatus* G. Tos, *Dichroplus exilis* G. Tos, *Dichroplus punctulatus* (Thunb.), *Dichroplus conspersus* Bruner, *Dichroplus vittatus* Bruner y *Dichroplus pratensis* Bruner.

3 — Los Gomphocerinae se alimentan casi exclusivamente de gramíneas, salvo raras excepciones como *Orphulella* sp. que come alfalfa. Las mandíbulas son de tipo Gm y las heces IA. Se localizan preferentemente en los bordes del alfalfar, pasando al centro sólo cuando el mismo está en decadencia, invadido por malezas, especialmente gramíneas. No pueden considerárselas como causantes de daños en los alfalfares.

4 — La familia Romaleidae prefiere en su dieta dicotiledóneas; en las especies colectadas en alfalfa la base de la alimentación es esta forrajera. Se las encuentra preferentemente en las zonas del alfalfar libre de malezas. Las mandíbulas son de tipo Fb y las heces IC. Son especies altamente peligrosas.

5 — Las especies del género *Dichroplus* Stal prefieren dietas variadas, lo que concuerda con los tipos de mandíbulas encontrados Fb o Hb. Las heces son de tipo IB o IC. Se trata de especies económicamente importantes en los alfalfares, especialmente *D. elongatus* y *D. exilis*.

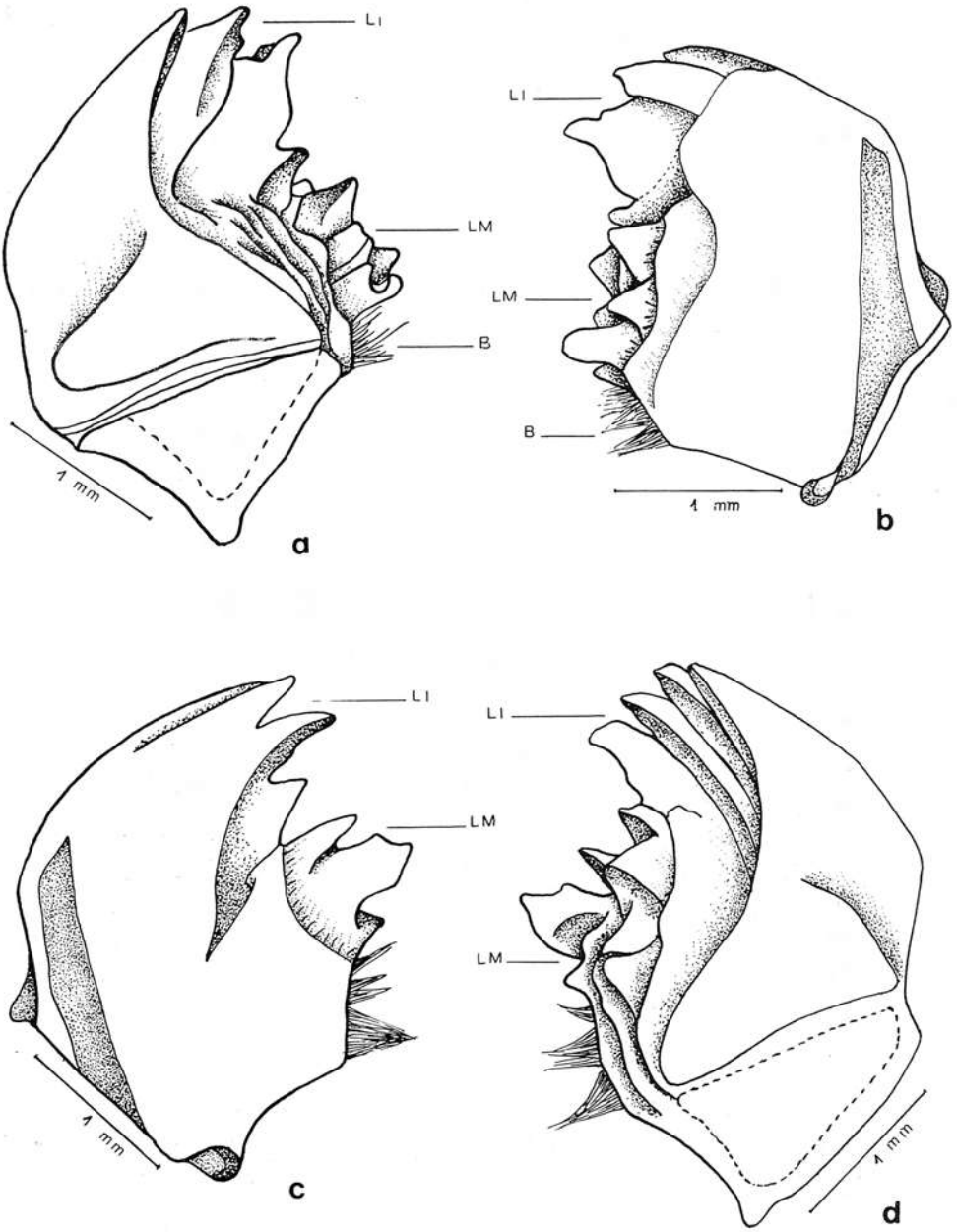

Fig. 1 – Mandíbulas de tipo Fb. de *Zoniopoda omnicolor* (Blanch.), macho. a, mandíbula derecha, vista ventral; b, vista dorsal; c, mandíbula izquierda, vista dorsal; d, vista ventral. LI, lóbulo incisor; LM, lóbulo molar; B, brustia.

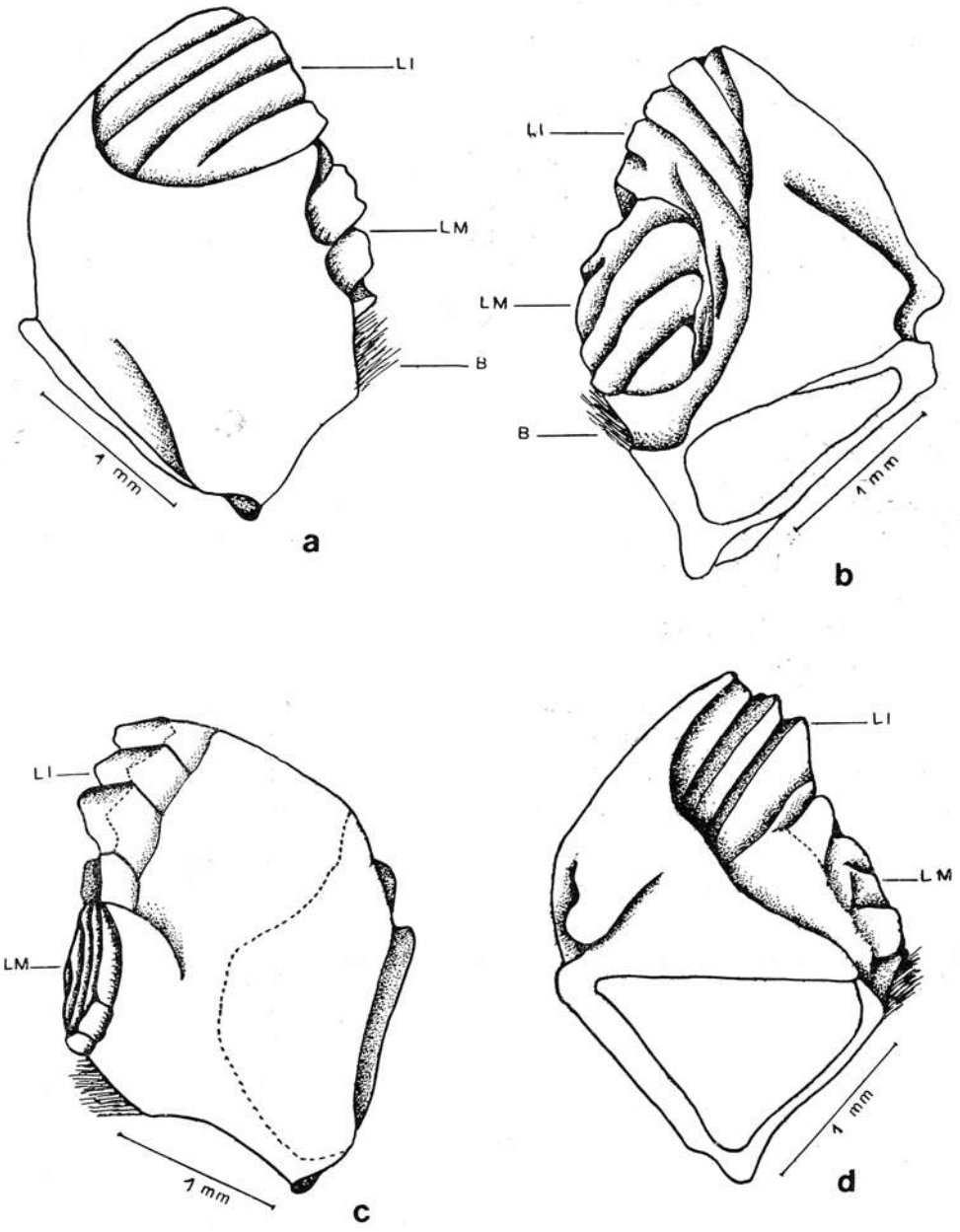

Fig. 2 – Mandíbulas de tipo Gm. de *Scyllinops bruneri* (Rehn), hembra. a, mandíbula izquierda, vista dorsal; b, vista ventral; c, mandíbula derecha, vista dorsal; c, vista ventral.

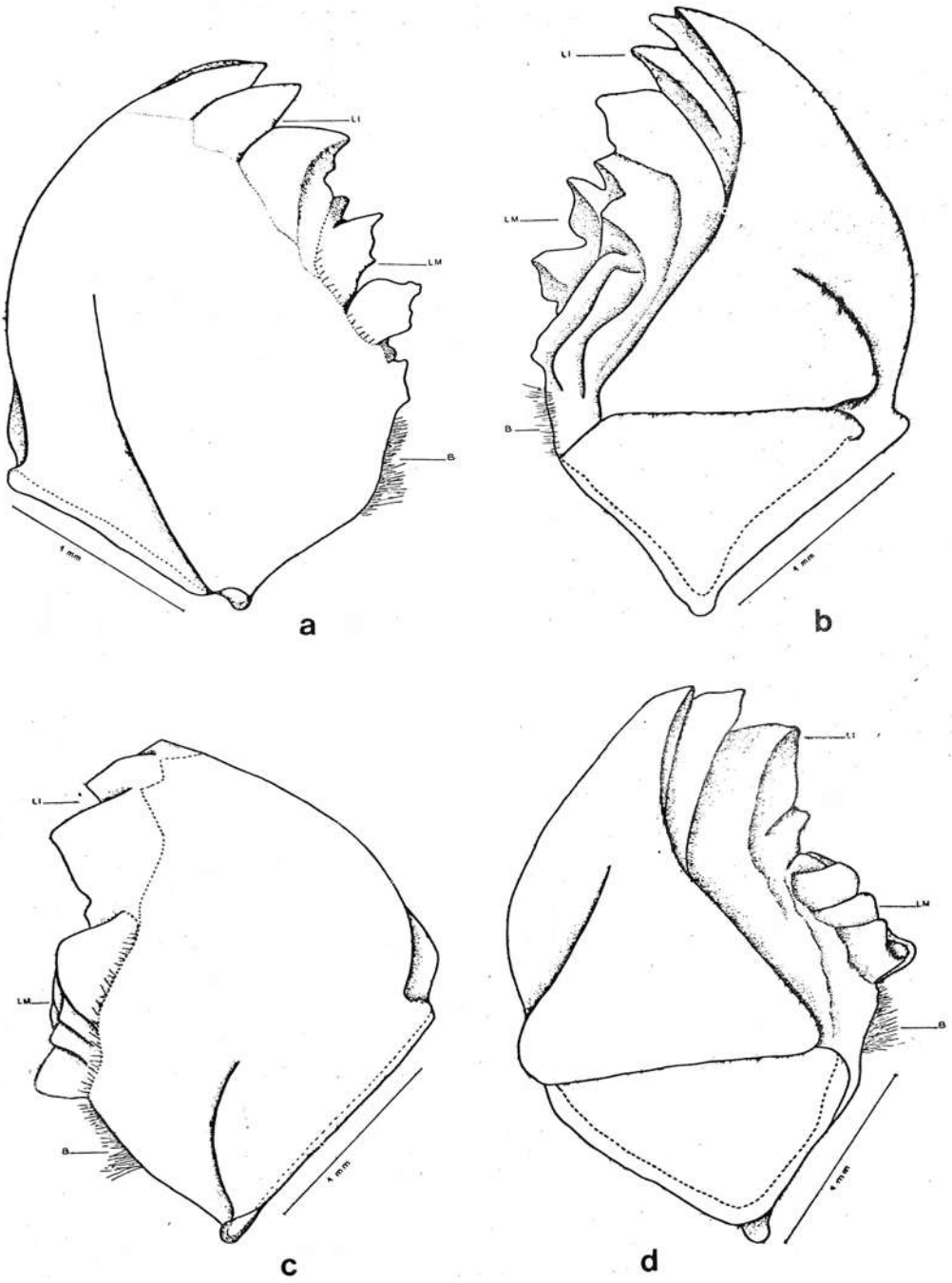

Fig. 3 – Mandíbula de tipo Hb. de *Dichroplus vittatus* Bruner, hembra. a, mandíbula izquierda, vista dorsal; b, vista ventral; c, mandíbula derecha, vista dorsal; d, vista ventral.

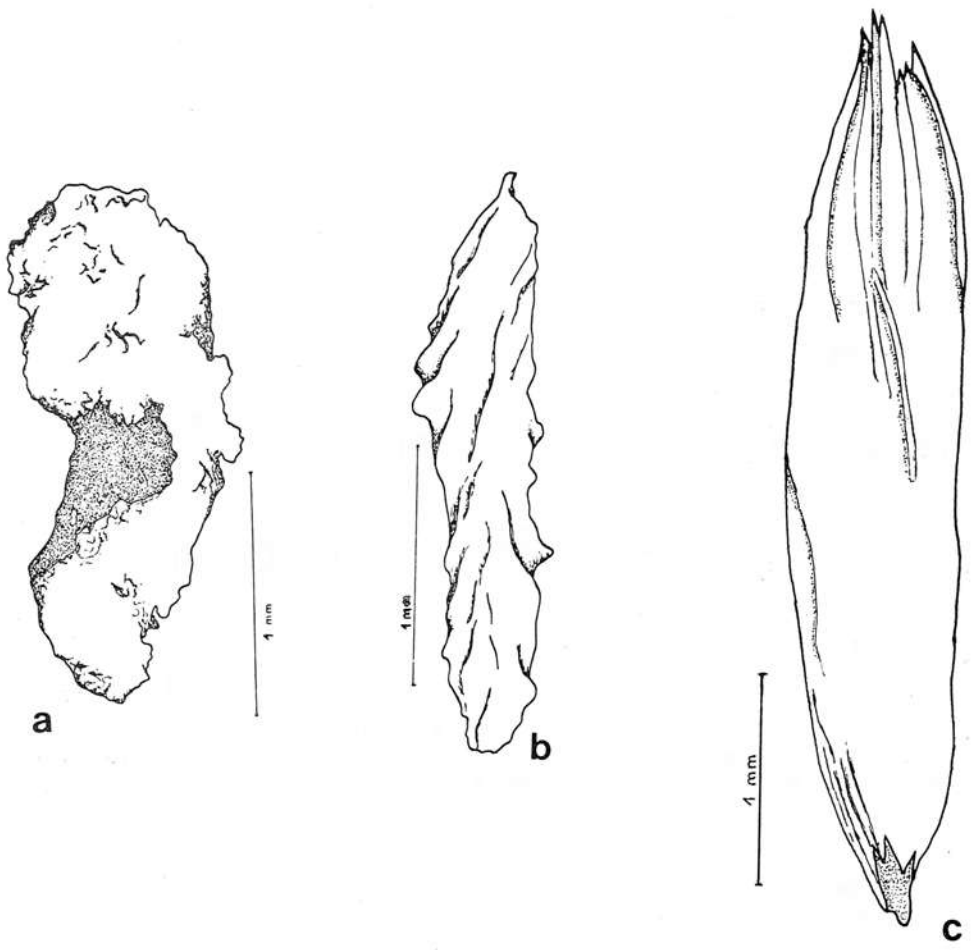

Fig. 4 – Heces. a, tipo IC asimétrica, compuesto de fragmentos no alineados de dicotiledóneas; b, tipo IB, semialineada, compuesta de partículas de di y monocotiledóneas; c, IA, alineada, constituida por restos de monocotiledóneas.

SUMMARY: This paper shows the results of an acridiological computation carried out in the alfalfa experimental fields at the Manfredi Agricultural Center in Córdoba, Argentine Republic.

The mandibles and the feculas of each one of the species are studied.

The species that include alfalfa in their diet, are determined and the role of each of them on the alfalfa fields, is specified.

Species belonging to Gomphocerinae feed on grass, so they do not damage alfalfa fields. On the other hand, those species belonging to Romaleidae and Melanoplinae, includ alfalfa in their diet.

The feculas content in 15 grasshoppers species is studied. The paper is completed with a detailed summary of the different types of mandibles and feculas.

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RESUMEN

APLICACION DE LA SEGMENTACION ANTENAL PARA EL CALCULO DE LA CANTIDAD DE ESTADIOS NINFALES O DE LA EDAD DE ADULTOS Y NINFAS DE ALGUNAS ESPECIES DE ACRIDIOS (ORTHOPTERA)

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La antena del adulto en diversas especies de acridios constituye un elemento informativo de su ontogenia. Esta afirmación es el resultado del estudio realizado sobre la segmentación antenal de acridios de la Argentina y se apoya en el agrupamiento de los antenitos del primer estadio ninfal según su capacidad de dividirse o no a lo largo de su ciclo de vida. El conocimiento de la metamería antenal conduce a calcular con exactitud la cantidad de estadios ninfales que tuvo cualquier individuo adulto, recurso que abre un panorama interesante para los trabajos ecológicos, pues su aplicación permitirá inventariar en condiciones de campo la variabilidad de la cantidad de estadios ninfales entre los individuos de una población. Hasta el presente el procedimiento se aplica a especies de los géneros *Aleuas, Amblitropidia, Chromacris, Dichroplus, Rhammatocerus, Schistocerca y Zoniopoda y en Allotruxalis y Elaeochora* con una ligera variante.

El examen del dibujo de antenas de especies exóticas (*Locusta migratoria, Dociostaurus maroccanus* y *Hieroglyphus nigrorepletus)* permite inferir que el cálculo de la cantidad de estadios ninfales también es válido.

Finalmente cabe expresar que el análisis de la antena de las ninfas determina el reconocimiento de la edad o de las mudas que han tenido.

RESUMEN

EL CONTROL DE LA LANGOSTA *SCHISTOCERCA PARANENSIS* (Burm.) EN LA REPUBLICA ARGENTINA, CON ALGUNAS CONSIDERACIONES SOBRE SU BIOECOLOGIA

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El conocimiento de la biología, ecología y comportamiento de la langosta *Schistocerca paranensis* (Burm.) aún tiene muchos puntos que a juicio del autor no se encuentran suficientemente claros. La presencia de sus dos fases: solitaria y gregaria, sigue siendo un tema apasionante, más aún casi novedoso. La implantación de un más o menos rígido plan de trabajos, que actualmente se halla en ejecución, permitirán en unos años establecer la interconexión existente entre ambas formas. Al mismo tiempo estas observaciones a campo se complementan con investigaciones de laboratorio referidas al estudio de su ciclo de vida, duración del período de incubación a diferentes temperaturas, estadios ninfales, madurez sexual, cópula, oviposición, etc.

Por otra parte se han iniciado una serie de experiencias para estudiar la razón de la aparición de las fases. Es un trabajo de largo aliento no exento de tropiezos.

DEVELOPMENT OF MICROBIAL AGENTS FOR THE CONTROL OF ACRIDIDAE

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ABSTRACT

The pathogenic microorganisms that are considered potentially useful as applied control agents include Entomopox viruses and the Protozoa, particularly *Malameba locustae, Nosema locustae, Nosema acridophagus,* and *Nosema cuneatum.* The selection and development of organisms as controlling agents depends on the host-environment-pathogen interrelationships that exist or will occur in the treated area. The factors concerning the pathogen that are considered important include virulence, host range, ease of mass production and prolonged storage, adaptability to efficient low cost application techniques, persistence, and potencial for registration as a microbial insectide. Field testing has demonstrated the feasibility of using *N. locustae* as a microbial agent, particularly for long-term control of grasshoppers (Orthoptera: Acrididae). Other organisms such as the viruses and *N. acridophagus* show potential as short-term controlling agents.

INTRODUCTION

A number of efforts were made toward the end of the nineteenth century to use microorganisms to control noxious Acrididae. Among the earliest reports of such studies were those dealing with the effects of various fungi on locusts by Kunckel D'Herculais and Langlois (1891) and Brongniart (1891). A few years later Edington (1898), in South Africa, and Brunner (1901), in the United States, reported natural epizootics among Acrididae caused by the fungus *Entomophthora (=Empusa) grylli.* During this same period, Kunckel D'Herculais (1900) reported on the natural and artificial propagation of fungi in Argentina. The efforts, reported in a review by Charles (1966), continued well into the present century. However, the most interesting and possibly the most controversial attempt to achieve microbial control of Acrididae began with a report by D'Herelle (1911) of an epizootic among Acrididae in Mexico caused by the bacterium then called *Coccobacillus acridiorum.* Later, D'Herelle (1914a,b) reported positive results when he used the bacterium to kill locusts and grasshoppers in parts of South America, particularly Argentina, and in Africa. However, subsequently other workers in Africa,

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particularly Sergent and L'Heritier (1914), Béguet (1915, 1916), and Sergent (1916), had highly variable results and in some cases lack of effectiveness. The work on *Coccobaccilus acridiorum* was then virtually discontinued, but investigations of other bacteria, and of their potential applied use, have continued.

It now is apparent that the efforts to use bacteria and fungi for control of Acrididae failed because these organisms generally require specific climatic conditions, namely high humidity, for growth and development. These organisms do play a significant role in regulating the densities of Acrididae in the tropical and subtropical parts of the world; however, they are not sufficiently dependable in the arid and semiarid regions of the world where grasshoppers and locusts are pests because of this dependence on high humidity. Therefore, microorganisms that are developed for applied use must be infective under a variety of conditions.

The Acrididae also are hosts to a number of pathogenic Protozoa and viruses that do not require specific temperature and moisture conditions for infection and that appear to offer great potential for applied use. These viruses include at least two Entomopox viruses and a picornavirus that we have isolated from grasshoppers in the United States, plus a picornavirus that was isolated in Australia from species of Gryllidae, but which also is pathogenic in Acrididae. One Entomopox virus, the grasshopper inclusion body virus (GIBV), has been fairly well characterized: the virions are quite large, about 350 nm long, contain DNA, and are occuluded in a protein inclusion body that apparently provides some protection to the virions (Henry *et al.* 1969). Viral replication occurs in the fat body of the host, and, when the virus is inoculated into third-instar nymphs, it usually causes death within 20 days. The host range includes species of the subfamilies Melanoplinae and Cyrtacanthacridinae. The other Entomopox is the *Arphia* pox virus (APV), which resembles GIBV both in structure and pathogenicity, but differs in that infections are limited to species in the subfamily Oedipodinae. The grasshopper picornavirus, known as the crystalline-array virus (CAV), is a small spherical virus, about 18 nm in diameter, that contains RNA, replicates in neuromuscular and muscular tissues, and causes death within 10 days when inoculated per os and within 6 days when injected (Jutila *et al.* 1970, Henry and Oma 1973). The host range includes species in the subfamilies Cyrtacanthacridinae, Melanoplinae, Oedipodinae, and probably the Gomphocerinae. When the cricket picornavirus was isolated by Reinganum *et al.* (1970), it could be compared to CAV and was then found to be structurally and pathogenically distinct. Within the Acrididae, we have inoculated it into *Schistocerca americana* (Drury) and *Melanoplus sanguinipes* (F.), but CAV, like all the pathogens discussed in this paper, undoubtedly has a much broader host range than currently documented.

The Protozoa that appear potentially useful include *Malameba locustae* (King and Taylor), an undescribed neogregarine, and 3 species of Microsporida. Also, a number of pathogenic protozoa are known and appear potentially useful, but have not been described.

Malameba locustae, an amoebic-type organism, infects the epithelial tissue of the midgut, gastric caecae, and Malpighian tubules of grasshoppers. It causes an insidious disease that results in density reductions more through reduced fecundity than through overt mortality. The host range, reported by King and Taylor (1936) and Taylor and King (1937), to include a large number of Acrididae, has now extended to include several species of Gryllidae. Although *M. locustae* is a serious pest in grasshoppers and locusts in laboratory cultures, Henry (1968), Donaldson (1971), and Henry and Oma (1975) reported that it can be easily controlled with antibiotics. The life cycle terminates in the development of a thick-walled cyst that is the resting stage when the organism is out of the host.

The undescribed neogregarine infects the digestive tract and fat body of various species of *Melanoplus*. The organism develops through several merogonic cycles as well as a sporogonic cycle that ultimately produces a large number of resistant spores. It appears to be quite virulent and is capable of causing density reduction through increased mortality as well as reduced fecuntity. Although the host range is expected to be much wider than presently known, relatively little work has been done with this organism because of difficulty with experimental transmission.

The Protozoa that appear to offer the greatest applied potential are 3 species of Microsporida belonging to genus *Nosema*. *Nosema locustae* Canning was described by Canning (1953, 1962) from *Locusta migratoria migratorioides* (Reiche and Fairmaire) and *Schistocerca gregaria* (Forskal) in laboratory cultures in England. Henry (1969a), extended the host range to include many species of Acrididae as well as some Gryllidae and it now appears that this pathogen will infect most species of Acrididae. *Nosema locustae* infects the fat body of acridids and thereby deprives the host of its energy reserves. Although Henry and Oma (1974a) demostrated that it is the least virulent of the 3 species of *Nosema*, it is sufficiently virulent to cause increased mortality and reduced fecundity in applied field tests (Henry 1971a; Henry *et al.* 1973; and Henry and Oma 1974b).

Nosema acridophagus Henry, which was described by Henry (1967) from *Schistocerca americana* (Drury), infects various tissues of species primarily in the subfamilies Crytacanthacridinae and Melanoplinae. Henry (1969b) showed that it induced tumor-like growths on the digestive tract. These growths caused lesions through which bacteria entered the hemocoel, and death of the host resulted from septicemia. *Nosema acridophagus* is the most virulent of the Microsporida; death usually results within 10 to 15 days after inoculation (Henry and Oma 1974a).

Nosema cuneatum Henry, which was described from a species of *Melanoplus* (Henry 1971b), infects the adipose tissue, including the pericardium. The virulence exhibited by this species is intermediate to that expressed by the other species of *Nosema*. Infections result in increased mortality within 18 to 20 days after inoculation as well as in reduced fecundity among the survivors.

CRITERIA FOR SELECTION OF PATHOGENS

The pathogens discussed exhibit characteristics that indicate their potential value in applied microbial control of the Acrididae. However, decisions about where and how to use them depend on the host environment-pathogen interrelationships that exist in the area or that will be established following introduction of the pathogen. Each of the factors of this triad can be examined separately.

Important Considerations About the Host

Unlike most applied entomological endeavors in which research is directed at the control of a particular pest species, the endeavor to control Acrididae deals with a number of species. However, relatively few species compete with man or his livestock for preferred forage to the point that they would be considered economically important. For example, of the 200 or so species of Acrididae in western United States, only 12 to 15 are considered economically important; most species are not important because they do not consume valuable plants or do not increase to high densities. Indeed, as Mulkern *et al.* (1969) pointed out, some species might be considered beneficial because they feed totally or predominantly on undesirable plants. For obvious reasons, applied microbial programs should be directed to the control of densities of the economically important species, and the other species should be used to maintain the existing enemies and any introduced pathogen.

As demonstrated by Mulkern *et al.* (1969), some species of Acrididae exhibit wide ranges of preferred host plants whereas other species are limited to a narrow range of food plants. Thus, *Melanoplus sanguinipes* is an economically important omnivorous

species that consumes grasses, sedges, broadleaf plants, plant debris, and animal tissue; but *Amphitornus coloradus* (Thomas), also an economically important species, feeds predominantly on 2 or 3 species of grasses. In addition, the food habits of some species change during development; young nymphs of *M. sanguinipes* feed almost exclusively on organic debris and small broadleaf plants, but older nymphs show an increasing preference for grasses. *Amphitornus coloradus* feed on the same kinds of plants during their entire development. These food habits of grasshoppers not only are important in relation to economics, but are also important from the standpoint of efficient use of pathogens because the host must consume the infectious stages of protozoa and viruses.

Important Considerations About the Environment

Although grasshoppers and locusts inhabit most land areas of the world, those species of greatest concern occur in the semiarid regions. In these regions, the Acrididae exist in a delicate balance with their natural enemies, primarily pathogenic microorganisms, other insects, and insectivorous vertebrates. Furthermore, these regions are characterized by variable and changing climatic conditions that, among other things, disturb this balance and cause yearly fluctuations and irregular distributions in the densities of grasshoppers and locusts. The resulting pattern is one of periodicity of peak densities, which, in most areas, occur at about 7- to 15-year intervals.

The main reason grasshoppers and locusts are serious pests in the semiarid regions is because they compete with domestic livestock for forage, which is limited and which is generally used to the maximum by the grazing animals during some part of the year. However, the limited amount of available forage usually causes the per unit value of the land (hectare or acre) to be very low and, therefore, justification for control of grasshoppers and locusts must be based on the value of the forage that is to be protected. In western United States, densities in excess of 8 grasshoppers per yd^2 are considered economically important, though this economic threshold does not take into account the question of whether these grasshoppers are of economically important species. Generally one or two predominant species in any complex in an outbreak will account for 70-80 percent of all grasshoppers, and these are usually economically important. However, control programs usually are not initiated until the densities exceed about 15 grasshoppers per yd^2 and until there exists a visible threat to standing forage. Thus, there is a difference between the economic and control thresholds. In the final analysis, all the factor, including the existing natural enemies, periodic outbreacks, economic and control thresholds, etc., must be considered in selecting and developing microbial agents.

Important Characteristics of Pathogens

From the characteristics of the host and environment, one can predict the characteristics of pathogens that are important and then select the pathogens that will be most effective. The characteristics that I considerer most important for effective use against the Acrididae are virulence, host range, efficient mass production and prolonged storage, ease of application, persistence, and probability of registration.

Virulence.—Every pathogenic agent exhibits a certain ability to produce disease in a particular host, and pathogens of Acrididae can be rated relative to each other in their ability to cause mortality within certain species; for example, *N. locustae* is much less virulent than *N. acridophagus* when inoculated in *M. sanguinipes*. This relative virulence tends to be constant among all species of Acrididae, providing, of course, that the pathogen is capable of initiating the infection in the first place. In insects, unlike

vertebrates, acquired humoral responses to infectious agents are not active. Therefore, once a pathogen overcomes the mechanical barriers and reaches a suitable tissue, the insect will either be killed or debilitated to some degree by the disease.

Another basic fact is that the virulence, or disease-causing ability, is inversely proportional to the natural incidence of that pathogen. The least virulent of all pathogenic protozoa, the gregarines, organisms that inhabit the digestive tracts of the Acrididae and other insects, are very common and frequently occur at a 100 percent incidence within certain grasshopper populations. In contrast, the most virulent pathogen, the crystallinne-array virus, has never been isolated or observed in field-collected Acrididae. This situation may result from the interaction between these organisms over a long evolutionary period, an interaction that has insured the survival of both pathogen and host. The importance of this is that in developing a microorganism for applied use the ability of that organism to cause disease and ultimately kill grasshoppers can be predicted from the natural incidence.

The selection of a highly virulent or a less virulent pathogen for a particular situation depends on the objective of the control program. Should the situation require rapid reduction in density, as in an outbreak that threatens a valuable crop, then a highly virulent organism should be selected. However, if long-term management of the densities of grasshoppers and locusts is required, as on low value rangelands, then a less virulent agent might be more effective. The development of *N. locustae* is being emphasized because it is sufficiently virulent to cause some short-term mortality but it is also sufficiently nonvirulent so as to persist in the population long after application. For example, one billion spores on 1.5 lb (680 gm) flaky wheat bran per acre (0.405 hectare) applied when the predominant species are third instar nymphs will cause about 50 percent reduction in density within 4 weeks, which is about the ovipositional period (Henry 1971a, Henry *et al.* 1973). Beyond the 4 weeks, the pathogen continues causing deaths, but it also reduces fecundity.

In the United States, some initial reduction in density is normally necessary because landowners and operators do not begin control practices until densities are well above the economic threshold. The short-term mortality achieved with *N. locustae* is then sufficient to reduce the densities to near or below the economic threshold and certainly below the control threshold. However, consideration has been given to the possibility of using *N. locustae* as a management tool rather than as a control agent. Such an approach would require periodic applications, about every 3 to 4 years, to prevent the development of damaging densities. The risk is that a situation might develop in which densities are maintained at such low levels that some existing natural enemies might be excluded to the point that they are no longer effective in contributing to control. This result might be analogous to excessive use of chemical insecticides by which natural enemies are totally eliminated, either directly or indirectly.

Host Range.— The host range exhibited by a pathogen is important because, as mentioned earlier, control is directed at a number of different species. In any one area where damaging populations develop, there may be anywhere from 20 to 50 species, but only 2 or 3 are dominant and economically important. However, the economic species may belong to different subfamilies so the pathogen must be capable of infecting most species in order to infect just the important ones.

The host ranges of pathogens of Acrididae generally show an inverse relationship with virulence: organisms that exhibit the most extensive host ranges are least virulent. Thus, *N. locustae* would be most useful for long-term control, but CAV or *N. acridophagus* would be more effective for short-term control, providing one or more of the predominant species are susceptible to infection. However, as demostrated in field tests (Henry *et al.* 1973), infection of all species in a complex is not necessary to achieve reductions in overall densities. For example, when the densities of the more susceptible species are reduced directly from disease following application of a pathogen, this reduction causes increased predation and parasitism of other species by the existing natural enemies, many of which have very wide host preferences. In recent field tests with *N. locustae,* numerous infections were observerd in 2 dominant species of *Melanoplus* that caused about 70 percent reduction in densities at 4 weeks post application, but very few infections were observed among the other 2 dominant species, *Aulocara elliotti*

(Thomas) and *Ageneotettix deorum* (Scudder). Nevertheless, the densities of these latter 2 species were reduced by about 50 percent compared with untreated checks (Henry *et al.* 1973). In these field tests, it appeared that the percentage of parasitism by entomophagous insects among the survivors of applications of *N. locustae* increases significantly following density reductions, a result that is much less likely when chemical insecticides are used because the chemicals are also toxic to parasitic insects.

Mass Production and Storage.– Mass production of any pathogen that is to be used for control is necessaty because outbreaks of grasshoppers and locusts are extensive and the organism must be applied over the entire affected area. Indeed, from the standpoint of effiency in use of equipment and personnel the production system should be operative during the entire year. This requires that the pathogen be stored for prolonged periods.

At the present, the viruses and protozoa that are being considered for microbial control of insects must be produced *in vivo*. Efforts to produce these organisms *in vitro*, as in cell cultures, are now showing promising results. However, the present indications are that monumental improvements will be required in cell culture techniques before the systems will be as practical or efficient as the insect host. Thus, all protozoa and viruses that are considered potentially useful against the Acrididae must presently be produced in insects. Unreported studies of the efficiency of producing *N. locustae* in *Melanoplus bivittatus* (Say) for large scale field tests demonstrated that *N. locustae* can be produced efficiently in this way. Moreover, the cost is relatively low, about $0.10 per acre (ca. $0.24 per hectare) dosage, which is considerably less expensive than present costs of chemical insecticide.

Both *N. acridophagus* and *N. cuneatum* are considered potentially useful for applied work as noted earlier. However, production of quantities sufficient for field testing has been difficult, partly because these pathogens are quite virulent and, partly because relatively few spores are produced in infected grasshoppers (Henry and Oma 1974b). However, recent studies have shown that these pathogens are infective in the corn earworm, *Heliothis zea* (Boddie), following special inoculative procedures, and it may be possible to produce large quantities of these spores at very low costs. Furthermore, assays have shown that spores, which are the infective stages of these organisms, produced in *H. zea* are much more infective and virulent in grasshoppers than are spores produced in grasshoppers. This use of alternative non-host insects for production may be potentially useful with other pathogens.

As Henry and Oma (1974b) reported, there is a significant loss in spore viability during storage of *N. locustae*. When spores are stored in water at -10° C about 90 percent of the viability is lost within 3 years. Also, there appears to be a serious loss in spore viability within 10 to 14 days after application to wheat bran prior to field application. Intensive studies will be necessary to develop procedures for preserving the viability of espores during prolonged starage and during field application. Such improved methods of preserving spore viability would significantly increase the efficiency of these pathogens and would reduce the cost of production and application.

Ease of Application.–Development of efficient low cost methods of appliction is essential for successful use of microorganisms against Acrididae because of the low values of the semiarid lands where grasshoppers and locusts are major pests. The development of ultra low volume (ULV) application was a significant factor in decreasing the cost of applying chemical insecticides and, similarily, microbials must be formulated and applied in concentrated forms in order to reduce airplane and equipment costs. However, because most pathogens must be consumed by the target insects, edible carriers must be used. Accordingly, spores of *N. locustae* are first applied to flaky wheat bran which is then applied at a rate of 1.5 lb./acre. With such treatment, one-tenth the number of spores are used to achieve results comparable to those obtained by ULV spraying of spores (Henry *et al.* 1977). But, carriers such as wheat bran, which is a bulky material, do increase costs of application compared with ULV application because of the reduced coverage per load. However, unlike ULV applications of chemical insecticides, full coverage of *N. locustae* or other pathogens is not essential, and retreatment of missed areas is not required. Also, microbials formulated in dry carriers can be applied at temperatures and wind regimens that cannot prevail during ULV applications of liquid materials. Therefore, there is greater efficiency in use of the airplane and crews, which reduces the cost. In addition,

the swath widths for wheat bran applications are regulated to a great degree by altitude of the airplane and so the swaths can be much wider than those recommended for ULV sprays. This means that the airplane is capable of covering more ground surface per swath, thereby reducing the flying time. In sum, the reduced coverage per plane load resulting from the increased bulk of the wheat bran can be balanced by other factors so the costs of applying wheat bran with a pathogen will probably be very comparable with the costs of applying a liquid spray.

Persistence.—A pathogen must be capable of persisting in the population following application and must continue to function as a controlling factor until the densities of the host are so low that they no longer support the pathogen. At this low point, the hosts are dispersed to such a degree that contact is infrequent and thus spread of the pathogen is reduced. Such a level of density should be well below the economic threshold.

Based on our numerous field studies, it appears that the persistence of a pathogen usually varies inversely with virulence, and so less virulent pathogens usually persist at lower host densities than do the more virulent pathogens. *Nosema locustae* continues to function as a controlling factor until the densities of grasshoppers are depressed to about 1 per yd^2, and infections by eugregarines, which are even less virulent, have been observed at fairly high frequency when host densities are lower than 1 per yd^2. In contrast, the results of unreported field studies demonstrated that infections by the Entomopox virus (GIBV) decreased markedly when host densities were reduced to about 3 to 5 grasshoppers per yd^2. Thus the choice of pathogen will determine to a great extent the level to which the host density will be reduced.

Registration.—In the United States, all microbial control agents must be registered as pesticides prior to general use. The authority for registration rests with the Environmental Protection Agency (EPA). Many other countries also have governmental bodies that regulate pesticides, and these administrative groups undoubtedly will approve or disapprove the use of various microbial agents. Therefores, if a pathogen is to be used, it must exhibit characteristics that will allow it to be registered for general use.
allow it to be registered for general use.

The protocols for registration in the United States and other countries have not been defined, but the main factors will be safety and efficacy. In other words, the microbial must be shown to be safe to use, and it must have a predictable effect.

There is a good deal of evidence that virtually all protozoan and viral pathogens that infect insects and also some bacterial and fungal pathogens are specific for insects. The main exceptions are arthropod-borne disease organisms such as malaria, dengue, various plant pathogens, etc. However, a pathogen that is being considered as a microbial control agent must undergo extensive testing to demonstrate non-infectivity for nontarget organisms. For example, mice, rats, guinea pigs, rabbits, fish, birds, and bees have been inoculated with *N. locustae* by a number of methods and have never shown infectivity, pathogenicity, or toxigenicity. Therefore, *N. locustae* is probably safe though some additional testing and constant screening may still be required. *Nosema acridophagus, N. cuneatum,* and *N. locustae* are likely to be similarly safe. Also, the Entomopox viruses are up to demostrate specificity for certain groups of insects, but the similarity of these viruses to the vertebrate pox viruses means that they must be tested even more extensively and thoroughly. Indeed, this similarity could prevent this use altogether because public acceptance may be lacking. The case of picornaviruses such as the crystalline–array virus of grasshoppers may be quite different. Although these viruses appear specific to insects, the small size of their genetic complement and the close similarity to such notorious mammalian viruses as poliovirus will probably prevent consideration or testing as microbial agents. It is because of these considerations that the pathogenic protozoa are receiving most of the emphasis in the development of microbial agents for use against Acrididae.

Efficacy of a product is important from the standpoint of consumer protection, and microbial insecticides, like chemical insecticides, will be labeled as to expected effectiveness. Effectiveness of chemical insecticides is determined by the toxicity per unit of active ingredient. This system, or one very similar to it, can be used with highly virulent organims that cause predictable mortality within a short period after application. However, the system will not be useful with less virulent organims that are being

developed for long–term control because the mortality and density reductions caused by these organims may not be obvious or predictable. The most appropriate alternative parameter for determining the efficacy of such pathogens may be the infectivity, that is, the percentage of infection that the formulation will produce in certain target species. This is the system used in defining the efficacy of formulations of *N. locustae* and it will probably be equally useful for most microbial agents developed for use against grasshoppers and locusts.

CONCLUSION

The development of any pathogenic microorganism for use against an insect is a very complex and involved process, and the development for use against grasshoppers may sometime be more difficult than for other agricultural pest such as the Lepidoptera. The major difficulties are: (1) the large number of different grasshopper species involved, each of which exhibits a particular susceptibility to each pathogen, (2) the highly irregular densities over both time and space and the irregular public support for control, (3) the fact that some important species are migratory, and (4) the fact that outbreaks are usually very extensive and may cover thousands of acres of relatively low–value land. As a result, microbial agents must be infective to a large array of species, persistent, effective under a variety of situations, and inexpensive.

The characteristics or factors that make grasshoppers and locusts highly suitable objects for microbial control include: (1) economic thresholds such that low densities can be tolerated, (2) exposure of the insects in nature during the entire growth and maturation, which makes it easier to reach them with microbial agents, (3) omnivorous consumption of food materials by pest species which allows a greater choice of carriers and (4) the fact that grasshoppers and locusts are natural hosts to a number of pathogenic microorganims that can be manipulated. The first and fourth characteristics. Acrididae are of particular importance because they allow flexibility and adaptability in the selection and use of microbial agents. Because the economic thresholds often allow the existence of low densities, longterm control programs with less virulent and probably less expensive organims can be employed in management programs. Microbial agents are now that will provide effective long–term control. Also, highly virulent agents are known that can give much the same quick control as chemical insecticides.

At present, no microbials have been developed to the point where they can be put into general use against the Acrididae. In fact, only *N. locustae* has been developed to the point where it has shown good potential for applied use. Other known pathogenes, particularly *N. acridophagus, N. cuneatum,* and *M. locustae,* have characteristics that would be as useful or even more useful than those of *N. locustae* for control of grasshopper and locusts. However, these are by no means the only pathogenic microorganims available. Some protozoa and viruses known in the Acrididae have not been isolated or studied. Also, I am sure serious surveys for pathogenic microorganisms in these insects in other parts of the world will produce useful microorganisms. The isolation, characterization, and development of these organims will require increased effort and cooperation between researchers throughout the world. Hopefully, such concerted effort will result in the eventual use of microbial agents in helping to maintain the densities of Acrididae at tolerable levels.

SUMMARY

Attemps during the early part of this century to control the dependence of these organisms on specific climatic conditions, namelay high himidity, for germination and survival. Accordingly, microbial control of Acrididae in the arid and semiarid regions requires selection and use of pathogens that function independently of any predisposing effects of climate. Protozoa and viruses have been

isolated that are pathogenic for grasshoppers and locusts under varied climatic conditions and that appear potentially useful as biological control agents. The viruses from grasshoppers include at least two Entomopox viruses and a picornavirus. Included among the Protozoa are the amoebic organism *Malameba locustae* an undescribed species of Neogregarinida, and 3 species of Microsporida, *Nosema locustae, N. acridophagus,* and *N. cuneatum.*

Selection of a pathogen for development as a microbial insecticide demands careful analysis of the host–environment–pathogen interrelationship that exists or will be established in the area of use. Factors considered important in relation to the host include the species complex, the food habits of the species, the seasonal developmental patterns, etc. Factors relating to the environment include the kinds and abundance of existing natural enemies, the value of the forage to be protected, and the damage thresholds involved. In evaluating pathogens, consederation must be given to characteristics such as virulence, host range, mass production and storage potentials, adaptability to efficient low cost application techniques, persistence in nature, and potential for registration as a microbial insecticide.

Nosema locustae has been tested extensively as a tool for managing the densities of Acrididae in western United States. These studies have demontrated that application of spores of *N. locustae* will cause reductions in densities through direc mortality and decreased fecundity. Other more virulent pathogens such as the viruses *N. acridophagus* and *N. cuneatum* appear more useful as short–term microbial insecticides.

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INFLUENCIA DE LA TEMPERATURA SOBRE LA RUPTURA DE LA DIAPAUSA EN CINCO ESPECIES DEL GENERO *DICHROPLUS* Y UNA ESPECIE DEL GENERO *CHROMACRIS*

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INTRODUCCION

La diapausa puede romperse exponiendo el huevo a temperaturas entre 0° y 10° C (Andrewartha, 1943; Andrewartha, 1944; Parker, 1930; Church y Salt, 1952). Es importante el momento de exposición al frío, pues el embrión debe desarrollarse parcialmente antes de someterlo a bajas temperaturas, con lo que luego se tiene una aceleración del crecimiento al sufrir temperaturas altas. El frío solubilizaría los elementos nutritivos de la yema poniéndolos a disposición del embrión para su posterior desarrollo (Andrewartha, 1943), o quizás disolvería las ceras ubicadas en la hidrópila con la consecuente entrada de agua al huevo (Slifer, 1946).

En este ensayo se estudian los requerimientos mínimos de frío para romper la diapausa, y una vez cumplido este requisito, las temperaturas favorables para la eclosión, en tucuras con diapausa obligatoria y facultativa. Las especies en estudio fueron: *Dichroplus elongatus* G. Tos; *D. bergi* Stal; *Dichroplus maculipenne* Blanchard; *Dichroplus pratensis* Bruner *Dichroplus pseudopunctulatus* Ronderos y *Chromacris miles* Drury. Al romperse la diapausa se reasume el crecimiento del embrión. Las secuencias del desarrollo embrional para distintas especies de ortopteros fueron establecidas por autores como Shulov y Pener (1959), Slifer (1932), Mathée (1951) y Riegert (1961).

MATERIALES Y METODOS

Se trabajó con material de diversa procedencia: ootecas de *D. bergi, D. elongatus, D. maculipenne* y *D. pratensis* del insectario de José C. Paz, ootecas de *D. maculipenne* de Laprida, ootecas de *D. pseudopunctulatus* de campos de José C. Paz y ootecas de *Chromacris miles* de campos de Castelar. Los desovadores fueron colocados el 22/4/76 en una casilla meterorológica en el campo, hasta totalizar las horas de frío requeridas en cada tratamiento (considerando como tales a las horas en las que la temperatura fue inferior a 7° C). Esta primera etapa de preincubación determinaría la ruptura de la diapausa. Luego se trasladaba el desovador correspondiente a cámara o a estufa, donde se cumplió la etapa de incubación con la subsecuente eclosión.

Para estudiar las características morfológicas del embrión, se lo fijaba en picroformol de Bouin antes de realizar la observación con binocular estereoscópico.

INFLUENCIA DE LAS TEMPERATURAS SOBRE LA LONGITUD DEL PERIODO DE INCUBACION Y EL PORCENTAJE DE NACIMIENTOS EN

D. ELONGATUS Y D. BERGI

Especie	Preincubación			Incubación				
	A	B	C	Recinto	Período (días)	Temp $\bar{X}$ (°C)	Nº de neonatas	°/o de nac.
Dichroplus elongatus	0	0	–	Cámara	170	20,8 ±2,1	13	69
				Estufa	–	–	–	0
	50	32	10,9 ±4,1	Cámara	50	20,2 ±2,4	17	89
				Estufa	21	29,8 ±1,4	20	88
	200	56	9,7 ±7,3	Cámara	48	21,0 ±2,3	21	91,1
				Estufa	17	29,2 ±3,2	20	79,9
	400	79	12,1 ±4,9	Cámara	57	19,5 ±2,3	15	100
				Estufa	17	28,5 ±3,9	17	66,2
	600	114	12 ±5,6	Cámara	37	21,8 ±1,4	14	85,7
				Estufa	16	25,5 ±3,5	17	93,9
	Total	187		Campo	(187)		21	100
Dichroplus bergi	0	0		Cámara	185(2rep)	21 ±1.1	10	60
				Estufa	106(2r)	28,8 ±3,5	6	35
	50	32	10,9 ±4,1	Cámara	53	20,1 ±2,4	11	68,6
				Estufa	23	29,8 ±1,4	13	61
	200	56	9,7 ±7,3	Cámara	61	20,2 ±2,1	17	97
				Estufa	18	29,1 ±3,2	16	97,5
	400	79	12 ±5,6	Cámara	57	19,5 ±2,3	19	95
				Estufa	22	28,4 ±3,9	15	96,6
	600	114		Cámara	37	21,8 ±1,4	16	97,3
				Estufa	21	25,5 ±3,6	16	100
	Total	194		Campo	(194)		21	100

INFLUENCIA DE LAS TEMPERATURAS SOBRE LA LONGITUD DEL PERIODO DE INCUBACION Y EL PORCENTAJE DE NACIMIENTOS EN

D. PRATENSIS Y *D. MACULIPENNE* (J. Paz)

	Preincubación			*Incubación*				
	A	B	C	Recinto	Período (días)	Temp. $\bar{X}$ (°C)	Nº de Neonatas	°/o de Nac.
Dichroplus pratensis	0	0	–	Cámara	125(1rep)	21,4 ±2	1	1,6
				Estufa	–	–	–	–
	50	32	10,9±4,1	Cámara	103	19,9 ±2,3	8	57,3
				Estufa	21	29,8±1,4	18	94,4
	200	56	9,7±7,3	Cámara	60	20 ±2,3	12	87,6
				Estufa	18	29,1±3,2	25	97,7
	400	79	12,1±4,9	Cámara	61	19,6±2,2	19	74,5
				Estufa	18	28,4±3,9	27	93,6
	600	114	12 ±5,6	Cámara	40	21,9±1,3	19	90
				Estufa	24	25,7±3,5	16	88,5
	Total	198		Campo	(198)		2121	98
Dichroplus maculipenne J. C. Paz	0	0	–	Cámara	172	20,8±2,1	8	40,07
				Estufa	–	–	–	0
	50	32	10,9±4,1	Cámara	63	19,9±2,4	16	71
				Estufa	54	29,5±3	5	22,3
	200	56	9,7±7,3	Cámara	77	20,2±2,1	18	77,3
				Estufa	37	27,7±3,1	18	88,4
	400	79	12,1±4,9	Cámara	56	19,8±2,2	20	95
				Estufa	15	28,5±3,7	25	94,9
	600	114	12 ±5,6	Cámara	37	21,8±1,4	20	94
				Estufa	19	25,4±3,5	22	100
	Total	197		Campo	(197)		17	98

INFLUENCIA DE LAS TEMPERATURAS SOBRE LA LONGITUD DEL PERIODO DE INCUBACION Y EL PORCENTAJE DE NACIMIENTOS EN

D. MACULIPENNE (Laprida), *CHROMACHRIS* y *D. PSEUDOPUNCTULATUS*

Especie	*Preincubación*			*Incubación*				
	A	B	C	Recinto	Período (días)	Temp $\overline{X}$ (°C)	Nº de neonatas	º/o de nac.
D. maculipenne Laprida (1 rep)	0	0	–	Cámara	–	–	–	0
				Estufa	–	–	–	0
	50	32	10,9±4,1	Cámara	36	20 ±2,2	18	100
				Estufa	20	29,7±1,4	13	65
	Total	197		Campo	(197)		18	100
Chromachris (1 rep)	0	0		Cámara	–	–	–	0
				Estufa	–	–	–	0
	50	32	10,9±4,1	Cámara	53	20,1±2,4	30	75
				Estufa	39	29,2±2,5	22	70,5
	600	114	12 ±5,6	Cámara	34	21,7±1,4	46	95
				Estufa	36	27 ±2,8	38	100
D. pseudopunctulatus	0	0	–	Cámara	148 (2 r)	20,4±2	1	7,5
				Estufa	23 (1 r)	29,4±1,8	17	100
	50	32	10,9±4,1	Cámara	56	20,1±2,4	17	85
				Estufa	21	29,8±1,4	15	100
	400	79	12,1±4,9	Cámara	42	19,4±2,3	13	86,5
				Estufa	36	28,8±3,2	17	100
	600	114	12 ±5,6	Cámara	29	22 ±1,5	15	89,5
				Estufa	14	25,8±3,5	21	100
	Total	192		Campo	(192)		16	100

COMENTARIOS

Analizando los resultados obtenidos vemos que no parece existir una relación definida entre los valores de porcentajes de nacimientos y el tratamiento que los determinará. En el tramiento de 0 hora (que no estuvo en el campo), no ocurrieron nacimientos en todas las repeticiones, ,y en aquellos casos en que sí hubo, el período de incubación excedió holgadamente el de los restantes tratamientos, alcanzando valores semejantes al período de incubación en el campo. Esto indica que en zonas cálidas donde la suma de horas de frío es menor de 50 (casos que no se da en nuestro país, Damario, 1969), si bien pueden ocurrir nacimientos, estos serán tardíos y aislados.

El período de incubación fue siempre menor en estufa que en el tratamiento correspondiente en cámara (donde las temperaturas eran casi 7° C más bajas), lo que nos sugiere la importancia que tienen las emperaturas altas luego de cubrir los requerimientos de frío. Esto viene a ser corroborado por el hecho de que los desoves que habían recibido 50 horas de frío en el campo, nacían una vez llevados a cámara o a estufa. No ocurría lo mismo con los desoves testigos (correspondientes al tratamiento de total) que habiendo sufrido igual cantidad de horas de frío sin nacer, al permanecer en el campo, por no darse las temeperaturas altas adecuadas. Las eclosiones recién ocurrieron a principios de noviembre, siendo la temperatura media de la última quincena de octubre de 16,3° C.

Se vió que el embrión de *D. elongatus* desarrolla hasta un estadio denominado VIII el cual se caracteriza como se detalla a continuación: embrión en anatrepsis. En vista ventral se aprecian las extremidades toráxicas articuladas distinguiéndose femur, tibia y tarso. El tercer par de patas cubre los dos rimeros urotergitos. Los tarsos se tocan en la línea ventral media. Segmentos abdominales divididos en uno medio y dos laterales. Maxila y labium claramente divididos se dirijen ventrad mediad. Largo: 1980 micrones. Ancho cefálico máximo: 940 micrones. Ancho córmico máximo: 720 micrones.

El desarrollo en estufa es mucho más veloz. Mientras el embrión demora dos meses y más para llegar al estadio VIII en condiciones naturales, en estufa lo hace en 30 días.

En ambos casos ocurre entonces una detención del desarrollo que puede prolongarse varios meses. Si el embrión recibe suficiente frío se reanuda el crecimiento ocurriendo blastokinesis y katatrespsis.

Se sabe que en *Austroicetes cruciata, Locusta migratoria migratorioides, Dosciostaurus maroccanus, Camnula pellucida, Hesperotettix sp., Melanoplus femur rubrum,* la diapausa ocurre al final de anatrepsis. En otras especies como *Melanoplus bivittatus* ese arresto del crecimiento se da justo antes de nacer. El caso de *D. elongatus* se asimila al de las especies del primer grupo donde la diapausa se da al final de anatrepsis.

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THE CHROMOSOMES OF A DISTINCTIVE PATAGONIAN ORTHOPTERAN INSECT, *CYLINDRORYCTES SPEGAZZINII* GIGLIO–TOS, 1914 (ORTHOPTERA – TRIDACTYLOIDEA – CYLINDRACHETIDAE).

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INTRODUCTION

Only seven species of Cylindrachetidae, one from New Guinea, five from Australia, and one from southern Argentina, have been described so far. For many years they were considered to be closely related to the mole crickets because of their body shape and the presence of a fossorial first pair of legs. In 1914 Giglio-Tos described*C. spegazzinii* and suggested that these strange insects are related to the embidiids rather than the mole crickets. Chopard (1918), however, found them related to the tridactylids. Crampton (1928), based on comparative corphology arguments, treated them again as gryllotalpids. It is Chopard's point of view which is the most widely accepted at present, and the cylindrachetids are now included with family rank within, the Tridactyoidea.

As far as the author knows, nothing up to date has been published on the cylindrachetid chromosomes. In the present paper, the chromosomes of *C. spegazzinii* are described and the cytological relationships with gryllotalpids and tridactylids discussed.

MATERIAL AND METHODS

A single male of *C. spegazzinii* collected in the locality of Bariloche, Neuquén Province, Rep. Argentina, at approx. 41° south latitude, on January 1973, was studied. The testes were fixed in ethyl alcohol-acetic acid (3:1) and stained with lacto-acetic orcein 2%.

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DESCRIPTION

The chromosome number of *C. spegazzinii* is 2n♂= 13 with a XO♂-XX♀ sex determining mechanism. The autosomes can be grouped into two pairs of large metacentric chromosomes and four pairs of medium size elements. Within the last group the longest pair is formed by acrocentric chromosomes while the remaining pairs are subacrocentric (fig. 2). Grouped in decreasing order of size, with the X chromosome at the end, the total length of the chromosomes given in arbitrary units, as well as the percentage of the shortest arm longitude over each total length are approximately as follows:

Chrom.	Long.	shortest arm. °/o
1	38	42
2	35	40
3	26	Very Small
4	23	17
5	20	10
6	15	13
X	43	28

During first prophase the second pair shows a heterochromatic segment at one of its ends (fig. 1, arrow). The X is submetacentric, the longest chromosome of the set and it appears completely heterochromatic during first prophase.

The, number of chiasmata was not measured but at first glance seems relatively high. The pairs four to six frequently show a chiasma in the small arm, as can be seen in the first metaphase of fig. 2.

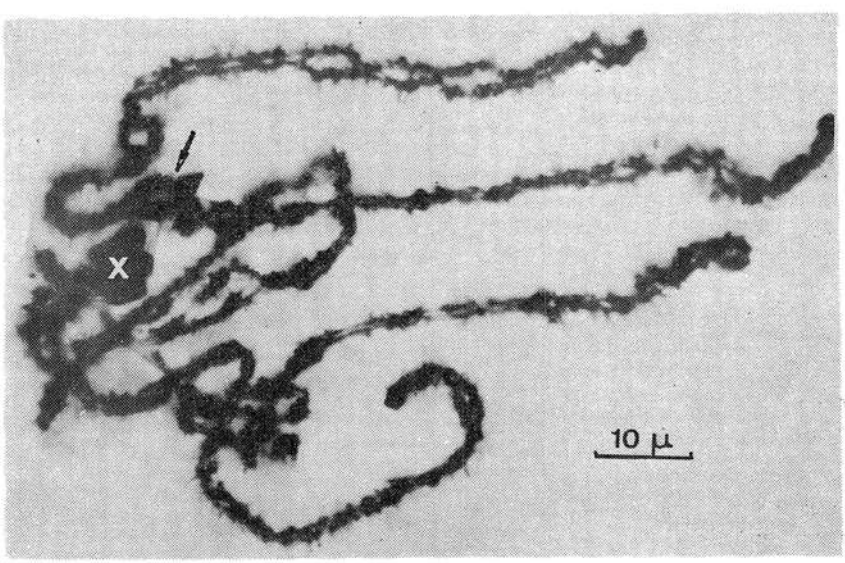

Fig. 1. *C. spegazzinii*. Very early diplotene.

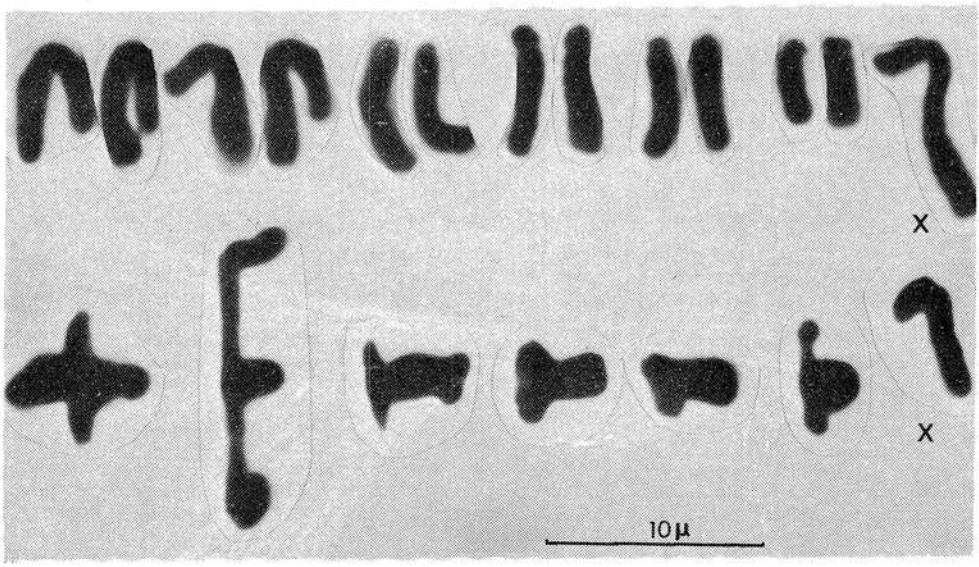

Fig. 2. *C. spegazzinii.* Above. Spermatogonial metaphase chromosomes in decreasing order of size with the X at the end. Below. First metaphase.

DISCUSSION

Cytological information on tridactylids is scanty. Ohmachi (1929) published on the chromosomes of *Tridactylus japonicus* which, according to that author, are 2n♂=13 with one pair of autosomes acrocentric while the remaining pairs are metacentric. The sex mechanism of this species is XO♂-XX♀. Powers (1942) mentioned the chromosome number of *T. sp.* and *Rhipipteryx sp.* as being 2n♂= 13 and 2n♂=15, respectively. Helwig (1958) added a drawing of a gonial metaphase of *R. sp.* Judging by his fig. 1, some of the autosomes seem to be metacentric. More recently, Gambardella (1976) published on the chromosomes of *R. notata* and showed a 2n♂= 15 with all the chromosomes either metacentric or submetacentric.

The information on mole cricket cytology is a little more extensive. The following species have a karyotype of 2n♂= 23: *Gryllotalpa africana* (Asana, Makino, and Niiyama (1940); Makino, Niiyama, and Asana (1940); Kushnir (1952); *G. himalayana* (Bhattacharjee and Manna (1967); *G. hexadactyla* (=*G. borealis)* (Payne 1912, 1916); White (1951); and *Scapteriscus tetradactylus* (Dreyfus 1942).

The species *G. gryllotalpa* has split into several cytological races which are apparently allopatric. However, from the taxonomic point of view, all of them seem to belong to a single species that extends over into Europe and the Mediterranean region. Their different karyotypes are as follows: 2n♂=12(XY) from France, Belgium, Germany, northern Spain, and northen Italy (Payne, 1916); de Winiwarter (1927, 1937); Ortiz (1951, 1958) 2n♂= 14 (XY) from Turkey and Rumania, (Steopoe, 1939); Kushnir (1952); 2n♂= 15 (XO) from southern Italy (Payne, 1916); de Winiwarter (1927, 1937); Barigozzi (1933); 2n♂=17 (XO) from southern Spain and probably central Italy (Ortiz 1951, 1958); Senna (1911); 2n♂=18 (XY) from northern Italy (Barigozzi 1942); Tosi (1959); 2n♂=19 (XO) fron Israel (a single locality) (Kushnir, 1948, 1952).

Two opposite interpretations have been advanced concerning chromosome evolution within the Gryllotalpidae. According de Winiwarter (1927, 1937), Barigozzi (1933), and Kushnir (1948, 1952), the lower chromosome number in mole crikets must be regarded as primitive. It is White's (1973) opinion, however, that 2n♂=23 has more chance of being the primitive number, and the changes in the chromosomal races of *G. gryllotalpa* must then have taken place by reduction through chromosomal fusion.

Judging, on the basic of the still fragmentary information on tridactylid chromosomes, the basic family karyotype seems to be 2n♂=13 or 15 with at least several pairs, including the X, metacentric or submetacentric.

If White's idea on mole cricket evolution is correct, the karyotype of *C. spegazzinii* with 2n ♂= 13 and two pairs of chromosomes plus the X submetacentric closely resembles the Tridactylidae rather than the Gryllotalpidae basic karyotype. Furthermore, this interpretation is in agreement with the taxonomist's modern point of view.

SUMMARY:

The karyotype of *C. spegazzinii* is 2n♂=13 with a X0♂-XX♀ sex mechanism. The autosomes comprise two pairs of large metacentric chromosomes and four pairs of medium size elements. Within the last group the longest pair is formed by acrocentric chromosomes while the remaining ones are subacrocentric.

The *C. spegazzinii* karyotype closely resembles that of the tridactilids.

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ABSTRACT
THE CURRENT STATUS OF NEW WORLD ACRIDOLOGY(1)

S. K. GANGWERE (2) & R. A. RONDEROS (3)

The locusts and grasshoppers, or Acrididae (Orthoptera), are among the most noxious of insects. We presently have a good understanding of the taxonomy of the Nearctic Fauna but know comparatively little about the insects'biology. Yet it is only through biological knowledge that there is promise of eventual control.

Our understanding of the Neotropical Fauna of Acrididae is far less complete than that of the Nearctic. Only a third or less of the species of the northern tier of South American Countries (Peru, Ecuador, Colombia, Venezuela, The Guianas, and Brazil) has been described. The fauna of the southern tier of countries (Chile, Argentina, Uruguay, Paraguay, and parts of Bolivia) is better understood, but most of the research has been in the alpha, or descriptive, stage of systematics.

It follows that more acridological research is needed, particularly at the *beta*, or interpretive, level of systematics. This is true both for the Nearctic and for the Neotropical Regions. These two regions, though widely separated geographically and different floristically and faunistically, share many biomes, have numerous ecologically equivalent species, and present similar acridological problems. Any advances made in our knowledge of one will inevitably contribute to our understanding of the other.

The enormity of the task which confronts acridologists is, in part, a consequence of the large numbers of species with which they must deal and, in part, a result of the paucity of active workers.

The present number of acridologists is insufficient even to deal with important taxonomic problems, to say nothing of biological and economic ones. Hence, an increased exchange of information and an intensified program of cooperative research, especially on an organized basis, appear necessary if we are to gain the knowledge that is requisite to effective control.

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NOTAS SOBRE BIOLOGIA, DISTRIBUCION Y COMPORTAMIENTO ALIMENTICIO EN CUATRO ESPECIES DE ACRIDIDOS CHILENOS

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Hemos elegido estas cuatro especies por ser representativas para todo Chile. En efecto, *Trimetropis ochraceipennis* es una especie que la podemos encontrar a lo largo y ancho de todo Chile. Desde las regiones desérticas de Arica en la Provincia de Tarapacá, hasta las frias regiones Magallánicas, pasando por las zonas semidesérticas del norte verde, las zonas de sabana de la zona central y las zonas australes.

Dichroplus elongatus es también una de las especies más comunes de Chile. Aunque su distribución es más restringida que la anterior, se le ha citado desde Coquimbo hasta Llanquihue. No por esto menos abundante y se le encuentra en casi todos los lugares donde se encuentre algo de pasto verde.

Las especies Moluchacris cinerascens y *Tetrixocephalus sergioi* son dos especies muy características de la zona Central y centro sur de Chile, ambas muy comunes, aunque en habitat más restringidos.

Nunca estas especies han sido estudiadas anteriormente en sus aspectos biológicos, ecológicos ni de comportamiento alimenticio. Sólo han sido objeto de estudios taxonómicos.

Trimerotropis ochraceipennis Blanchard

Como ya se dijo es una especie de muy amplia distribución de Norte a Sur y de mar a cordillera.

Los primeros ejemplares se pueden encontrar, en la zona central, desde las primeras semanas de septiembre. Los adultos es frecuente encontrarlos hasta las últimas semanas de mayo y primeras de junio. Las ninfas recién nacidas, son muy semejantes a las de *Tetrixocephalus sergioi,* pero tienen unas gruesas bandas negras en el tercer par de patas y en el abdomen. Los primeros adultos se pueden encontrar en las primeras semanas de noviembre.

Su desarrollo es de aproximadamente 57 días. Se la encuentra de preferencia en lugares asoleados y secos. En las márgenes de los caminos, entre los claros de los matorrales, en las laderas asoleadas de los cerros, pequeñas colinas pedregosas, en las márgenes arenosas y secas de los ríos. Siempre viven en grupos, que en ocaciones son muy numerosos. Prefieren aquellos lugares más secos de tierras sueltas y polvorientas o arenosas. Estos lugares en invierno y primavera presentan una vegetación aunque escasa, por lo menos verde y tierna. Pero a fines de primavera, verano y comienzos del otoño, este estrato verde se seca, alimentándose los ejemplares del resto de la vegetación seca.

Tanto las ninfas como los adultos presentan una notable homocromía, que se hace más evidente en los ejemplares adultos. Debido a esto la coloración de los ejemplares es muy variable, siendo el color básico ocre con manchas negras. No es raro encontrar ejemplares amarillo con negro, rojo ferrugíneo con negro, celestes con negro, café con negro e incluso plomo uniforme muy oscuro. La variación cromática se manifiesta incluso entre ejemplares de habitat muy restringidos.

Por el análisis de sus mandíbulas se puede concluir que es una especie del tipo herbívoro. Come tanto monocotilas como dicotilas. De las monocotilas come gramíneas, que pueden ser secas o verdes. Estas plantas abundan en los lugares secos en que se encuentra *Trimerotropis ochraceipennis,* de las dicotilas comen de preferencia representantes de las familias Geraniaceae, Solanaceae, Compositae, Scrophulariaceae y Chenopodiaceae.

Sus heces corresponden al tipo 1B.

Materiales estudiados:

Arica (Tarapacá) 16 noviembre 1952, Herrera Col.; Azapa (Tarapacá) Herrera col.; Villa Industrial (Tarapacá) 7 febrero 1953, Herrera col.; Chapiquiña (Tarapacá) 24 noviembre 1966; Herrera col.; Putre (Tarapacá) 26 febrero 1948, Etcheverry col.; Poroma (Tarapacá) 9 marzo 1948, Herrera col.; Belén (Tarapacá) 24 diciembre 1966, Herrera col.; Caritaya (Tarapacá) 19 agosto 1954, Herrera col.; Imagua (Tarapacá) 20 octubre 1971, Herrera col.; Mamiña (Tarapacá) 21 mayo 1968, Herrera col.; Qda. de Toconce (Antofagasta) 4 diciembre 1959, Herrera col.; Tumbre (Antofagasta) 12 febrero 1966, Las Chimbas (Antofagasta) junio 1958, Herrera col.; Siloli (Antofagasta) 18 enero 1967, Herrera col.; Piedra Colgada (Atacama) 19 octubre 1965, Etcheverry col.; Monte Amargo (Atacama) 28 agosto 1965, Etcheverry col.; Algarrobo (Atacama) 20 septiembre 1965, Zapata col.; Las Juntas (Atacama) 11 diciembre 1965, Zapata col.; San Antonio (Atacama) febrero 1965, Pino col.; Chañarcillo (Atacama) 15 diciembre 1965, Zapata col.; Castilla (Atacama) 10 diciembre 1965, Zapata col.; Paihuano (Coquimbo) 2 marzo 1957, Herrera col.; Limarí (Coquimbo) 30 octubre 1970, Herrera col.; Socos (Coquimbo) 27 noviembre 1964, Etcheverry col.; Termas Socos (Coquimbo) 27 noviembre 1964, Herrera col.; Talinai (Coquimbo) 25 octubre 1964, Herrera col.; La Laja (Coquimbo) 25 octubre 1970, Zapata col.; Jahuel (Aconcagua) 23 diciembre 1963, Zapata col.; Cuesta el Melón (Valparaíso) 30 noviembre 1068, Pérez de Arce col.; Casa Blanca (Valparaíso) 18 enero 1967, Herrera col.; Algarrobo (Valparaíso) 10 marzo 1965; Qda. de Córdova (Valparaíso) Zapata col.; Qda. de San Jerónimo (Valparaíso) Zapata col.; Polpaico (Santiago) Etcheverry col.; Quilicura (Santiago) Herrera col.; Colina (Santiago) Etcheverry col.; San Ignacio (Santiago) 11 diciembre 1975, Zapata col.; Las Chilcas (Santiago) 26 noviembre 1974, Etcheverry col.; Lampa (Santiago) 7 enero 1968, Zapata col.; Renca (Santiago) 9 octubre 1964, Zapata col.; La Reina (Santiago) Etcheverry col.; Peñalolén (Santiago) 8 enero 1964, Zapata col.; San Cristóbal (Santiago) Etcheverry col.; La Pincoya (Santiago) febrero 1975, Moyla col.; Macul (Santiago) febrero 1948, Etcheverry col.; El Principal (Santiago) 11 noviembre 1975, Zapata col.; El Arrayán (Santiago) 9 febrero 1966, Herrera col.; Puente Alto (Santiago) 22 noviembre 1971, Etcheverrycol.; San Alfonso (Santiago) Pérez col.; Los Maitenes (Santiago) Herrera col.; Corral Quemado (Santiago) noviembre 1968, Herrera col.; El Volcán (Santiago) marzo 1948, Etcheverry col.; El Canelo (Santiago) diciembre 1958, Ramírez col.; Cuesta la Dormida (Santiago) 30 noviembre 1968, Herrera col.; Isla de Maipo (Santiago) Toro col.; Cerro Chena (Santiago) 4 diciembre 1964, Zapata col.; Talagante (Santiago) febrero 1960, Zapata col.; Malloco (Santiago) 11 noviembre 196, Etcheverry col.; El Tabo (Santiago) 25 febrero 1964, Pino col.; El Canelillo (Santiago) Etcheverry col.; San Sebastián (Santiago) febrero 1975, Moyla col.; Angostura de Paine (O'Higgins) enero 1964, Herrera col.; Termas de Cauquenes (O'Higgins) 25 enero 1969, Herrera col.; Termas del Flaco (Colchagua) Etcheverry col.; La Balsa (Linares febrero 1975, Contreras col.; Cobquecura (Ñuble) 7 febrero 1962, Charlín col.; Las Trancas (Ñuble) febrero 1965,

Herrera col.; Termas de Chillán (Ñuble) febrero 1965, Etcheverry col.; Punta Carranza (Malleco) 2 febrero 1962, Charlín col.; Jaula (Malleco) Charlín col.; Termas Río Blanco (Malleco) 11 febrero (Malleco) 7 febrero 1963, Herrera col.; Termas de Palquín (Cautín) 14 febrero 196, Etcheverry col.; Valdivia (Valdivia) Wagenknecht col.; La Unión (Valdivia) 1 marzo 1972, Leighton col.; Osorno (Osorno) Ramírez col.; Petrohué (Llanquihue) Herrera col.; Guabún (Chiloé) enero 1959 Herrera col.; Cohaique (Aysén) 3 marzo 1969, Herrera col.; Punta Arenas (Magallanes) Herrera col.

Dichroplus elongatus G. Tos

Como ya se dijo es esta una especie muy característica de Chile con una distribución bastante amplia . Se le encuentra de preferencia en lugares con bastante pasto tierno y suelo húmedo. En algunos casos se convierte en un serio peligro para los campos cultivados, en especial de empastaduras con alfalfa o trébol. También se le ha citado como plaga del arroz, en la zona centro sur de Chile. Igualmente es frecuente que ataque a cultivos de acelgas, perejil y zanahorias.

Prefieren lugares en que la vegetación sea abundante y hemos observado que en estos lugares por lo general hay tres sustratos vegetales: uno muy bajo formado de pequeñas gramíneas y plantas rastreras. Es en este estrato donde viven corrientemente las hembras, ya que por su tamaño y peso les es difícil el vuelo. Hay un segundo estrato un poco más alto, formado de preferencia por plantas entre 15 y 20 cm de alto, es en este estrato donde se encuentran los machos, aunque también es frecuente encontrarlos en un tercer estrato, formado por plantas altas o subarbustivas. Las hembras, ante un estímulo prefieren esconderse bajo las hojas de pequeñas plantas, sólo vuelan cuando el estímulo es muy fuerte. Los machos vuelan y se desplazan con rapidez.

Las ninfas comienzan a aparecer en las primeras semanas de septiembre. Su desarrollo dura aproximadamente 52 días. Las ninfas son muy activas y en las horas de calor se las encuentra comiendo sobre hojas, incluso en hierbas altas. La postura se desarrolla en las horas de más calor y dura aproximadamente 1 o 2 minutos.

La especie es del tipo herbívoro. Se alimenta de gran número de gramíneas y otras tantas dicotiledoneas entre estas de las siguientes familias: Compositae, Cruciferae, Solanaceae, Chenopodiaceae, Umbelliferae, Polygonaceae, Plantaginaceae, Portulacaceae y Verbenaceae. Sus heces corresponden al tipo 1 A.

Material Examinado:

Paihuano (Coquimbo) 6 marzo 1965, Wagenknecht col.; Casa Blanca (Valparaíso) 18 enero 1967, Etcheverry col.; Runge (Santiago) 25 enero 1967, Etcheverry col.; Lampa (Santiago) febrero 1976, Zapata col.; Pudahuel (Santiago) 28 enero 1951, Herrera col.; Renca (Santiago) febrero 1951, Montes col.; San Cristobal (Santiago) febrero 1951, Herrera col.; Macul (Santiago) marzo 1969, Zapata col.; El Arrayán (Santiago) octubre 2951, Herrera col.; San Alfonso (Santiago) Pérez col.; Apoquindo (Santiago) 26 marzo 1951, Ramírez Col.; El Canelo (Santiago) 26 marzo 1959, Herrera col.; Los Maitenes (Santiago) Pérez col.; La Pincoya (Santiago) febrero 1975, Moyla col.; Talagante (Santiago) 23 noviembre 1964, Zapata col.; El Tabo (Santiago) 5 febrero 1964, Pino col.; Cerro chena (Santiago) 6 enero 1964; Angostura de Paine (O'Higgins) enero 1964, Herrera col.; Termas de Cauquenes (O'Higgins) 15 enero 1969, Herrera col.; Talca (Talca) Etcheverry col.; Jauja (Malleco) 11 febrero 1962, Charlín col.; Termas de Río Blanco (Malleco) Zapata col.; Contulmo (Malleco) 7 febrero 1963, Herrera col.; Cobquecura (Ñuble) 7 marzo 1962, Charlín col.;

Tetrixocephalus sergioi Ronderos

Es esta una especie muy característica de la zona central de Chile. Se le encuentra de preferencia en lugares secos y arenosos, en especial en las márgenes de los rios o lechos de rios secos. Prefieren los habitat secos y calurosos. Cuando el calor se hace intenso, los ejemplares, tanto adultos como inmaduros, se entierran en la arena. Lo mismo hacen por las noches.

En cautiverio la especie practica un alto canibalismo. No hemos detectado esta costumbre en la naturaleza, aunque en sus primeros estadios de desarrollo se encuentra en grandes cantidades en superficies bastante restringidas.

Su desarrollo dura aproximadamente 50 días y muda entre tres y cuatro veces.

La postura se realiza en la arena seca y suelta y las hembras prefieren aquellos lugares más altos, libres de posibles inundaciones.

Cuando nacen, las pequeñas ninfas permanecen junto a los lugares de nacimiento y poco a poco comienzan a desplazarse, aunque vuelven a reunirse por la noche bajo la arena y en los lugares que han nacido. Ya adultos se desplazan e invaden otros lugares relativamente próximos. La cópula se efectúa a las horas de más alta temperatura y al sol. Los machos efectúan un pequeño cortejo ante las hembras que consiste en dar algunas vueltas alrededor de la hembra levantando el tercer par de patas y caminando con un andar de lado.

La especie se alimenta de gramineas, secas o verdes, y dicotiledoneas. De preferencia comen Chenopodiceae, Solanaceae, Compositae, Geraniaceae. Por sus mandíbulas corresponden al tipo de herbívoro. Sus heces corresponden al tipo 1 A.

Material examinado:

La hemos colectado por el norte Polpaico y por el sur hasta Guabún. Polpaico (Santiago) febrero 1972, Zapata col.; Lampa (Santiago) febrero 1974, Zapata col.; Renca (Santiago) febrero 1972, Zapata col.; San Sebastián (Santiago) febrero 1975, Moyla col.; Puente Alto (Santiago) 14 enero 1976, Zapata col.; Peumo (Talca) febrero 1949; Guabún (Chiloé) 15 enero 1951, Herrera col.

Moluchacris cinerascens Philippi

Es este un hermoso acridido áptero, grueso y de color terroso que le permite pasar inadvertido la mayoría de las veces. Siempre se le encuentra en contacto con el suelo. Escondido entre la hojarasca o al amparo de piedras. Nunca trepa a los arbustos o hierbas.

Prefieren los habitat secos como laderas de cerros, lechos de rios sin agua, márgenes de caminos rurales. Viven solos y nunca en grupos.

La cópula se desarrolla en las horas de más alta temperatura, las hembras llevan sobre el dorso a los machos por algunas horas. Las hembras pueden desplazarse de lugar y comer durante la cópula. Su desarrollo es de aproximadamente 57 días. Se la encuentra desde las últimas semanas de Agosto, hasta fines de Mayo. Muda entre tres y cuatro veces durante su desarrollo.

En su alimentación se consumen tanto monocotilas como dicotilas. Entre estas últimas, representantes de las familias Geraniaceae, Chenopodiceae y Plantaginaceae. Su armadura bucal corresponde al tipo herbívoro y sus heces al tipo 1 A.

Material examinado:

Renca (Santiago) 9 octubre 1964, Zapata col.; El Arrayán (Santiago) nov. 1964, Zapata col.: Lagunillas (Santiago) 23 noviembre 1971, Etcheverry col.; El Principal (Santiago) 11 noviembre 1975, Zapata col.; Malloco (Santiago) 11 noviembre 1966, Etcheverry col.; Talagante (Santiago) febrero 1954, Herrera col. Qda. San Francisco (Santiago) 1 mayo 1960; El Canelillo (Santiago) 7 octubre 1965, Etcheverry col.; Talca (Talca) 30 enero 1956, Etcheverry col.; La Balsa (Linares) febrero 1976, Contrera col.; Cerros de Nahuelbuta (Angol) 9 diciembre 1950, Bullock col.

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RESUMEN
ESTUDIOS BIO–ECOLOGICOS SOBRE SIETE ESPECIES DEL GENERO *DICHROPLUS* Stäl

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Dentro del grupo de las "tucuras" dañinas para la agricultura, el género *Dichroplus* Stäl ocupa un lugar de primerísima importancia. A pesar de lo mucho que han sido combatidas las diferentes especies, se conoce poco en detalle sobre la biología de las mismas.

Por el momento se ha centrado la atención sobre siete especies, todas ellas representadas en el noroeste argentino, a saber: *D. bergi* Stal; *D. elongatus* G. Tos; *D. exilis* G. Tos; *D. pratensis* Bruner; *D. puntulatus* (Thunberg); *D. schulzi* Bruner; *D. vittatus* Bruner.

Se han estudiado las especies en las distintas fases de su ciclo vital. *Huevos:* forma, tamaño, disposición en el desove, tipo de diapausa, tiempo de incubación a diferentes temperaturas. *Ninfas:* duración de los diferentes estadios, aparición o no de estadios "extras"; caracterización de cada estadio por su coloración, desarrollo de las pterotecas y evolución de la terminalia. *Adulto:* maduración sexual, cópula y oviposición, número de posturas por hembra, frecuencia de oviposición, etc.

Se realizaron experiencias con algunas especies, con el fin de determinar la viabilidad de los huevos con el transcurso del tiempo y la tolerancia de los mismos a inmersiones prolongadas, llegándose a resultados de sumo interés.

Como consecuencia de la cria sucesiva en laboratorio, se contribuye con una novedad, que es la aparición de formas macrópteras en *Dichroplus schulzi* Bruner, que hasta la actualidad no han sido mencionadas en la literatura especializada. La explicación de este hecho, como así también su eventual aparición en la naturaleza, es objeto de estudios actuales.

RESUMEN
ESTUDOS CROMOSSOMICOS EM TETTIGONIIDAE (ORTHOPTERA)

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Nos ultimos anos temos estudado citologicamente um grande numero de especies de tettigonidos pertenecentes principalmente as subfamilias: Phaneroterinae, Cophirinae, Litroscelinae, Conocephalinae, Decticinae, Tympanophorinae e Pseudophyllinae. Os cariotipos basicos destas subfamilias e suas alteraçoes de correntes de fusoes autossomicas, de inversoes e dissosiaçoes serao discutida como fontes basicas da evoluçao da familia. A evoluçao do mecanismo cromossomico de determinaçao sexual sera revisto considerando - se a heterocromatinizaçao nos autossomos incorporados aos novos sistemas originados por translocaçoes. Será feita una tentativa de establecimiento de relaçoes filogeneticas entre as sub-familias, fundamentadas essencialmente em studos cromossomicos.

ORIGIN, EVOLUTION, AND DISTRIBUTION OF THE NEOTROPICAL ACRIDOMORPH FAUNA (ORTHOPTERA): A PRELIMINARY HYPOTHESIS

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INTRODUCTION

The existing knowledge of the Neotropical fauna of acridomorph insects (Proscopiidae and Eumastacidae included), especially in regard to its systematics, geographical distribution, and paleontology, does not allow us to ascertain the past history or origin of its elements. A recent renewal of interest in its study, however, has resulted during the last few years in a number of important papers (mainly by Amedegnato, Descamps, Kevan, Roberts, and Ronderos) that substantially contribute to our knowledge and provide a basis for interpretacion.

The recent works are based on the considerable volume of research accumulated by the scientists who laid the foundations of Neotropical acridiology, such as Bolivar, Bruner, Brunner von Wattenwyl, Burmeister, Giglio, Tos, Hebard, Liebermann, Rehn, and Stal, to mention only the most prominent. The aforementioned recent studies allow us to systematize and understand better the data provided by the older papers.

Among the recent contributions to the systematics of the Neotropical Acridomorpha are those of Amedegnato (1974 principally) that have become indispensable for any attempt at interpretation of the fauna's origin and distribution. Without Amedegnato's classification, the present paper and similar contributions would be impossible. Unfortunately, Amedegnato's complete thesis, of which the mentioned 1974 paper is only a small part, has not yet been published. Judging only by her classification, it seems to me that said thesis will be the most important contribution of recent times to the systematics of the Neotropical acridomorphs.

Also during the last ten or fifteen years, in an entirely different field of knowledge, important advances have been made that have a decisive bearing on interpretation of evolution and zoogeography. I refer to recent research in geophysics, particularly as related to continental drift and plate tectonics. Together with modern studies in paleogeography, paleontology, and stratigraphy, they allow us to interpret the known facts about the Neotropical biota in a different and more rational way. These interpretations will probably be closer to the truth than the previous ones that were based on the idea of fixed, invariable relative positions of the continents, islands, and oceans throughout geological time.

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Modern knowledge of the stratigraphy and paleontology of Central America and the northwestern corner of South America particularly provides a more adequate picture of the relationships between North and South America and hence, of the possibilities of biotic interchange from the Cretaceous to Recent times. This contributes to a more adequate knowledge of the origin of the South American fauna.

Another relatively new piece of information that cannot be ignored anymore for interpretation of the evolution of the South American fauna is the probability that the Pleistocene glaciations influenced in a radical way the climate and distribution of the plant formations and corresponding fauna during the aforementioned epoch. A series of alternating periods of cold and dry and warm and humid climates caused corresponding retreats and expansions of tropical rain forest. During glacial periods, this jungle was reduced to a series of "islands" or "refuges", located mainly at the periphery of the present Amazon basin. Other plant formations such as the prairies or the Andean paramos underwent a similar process but in the opposite phase, expanding and coalescing during the glacial periods, retracting and fragmenting during the interglacial ones. These episodes determined the isolation in "refuges" of the elements of the tropical biota, and lead to the corresponding speciation and later re-mixing of the resulting species in interglacial periods such as the present one. The myth of the immutability of the tropical jungle has been destroyed, and, in this way, the richness and multiplicity of its species can now be understood. The concept of a series of episodes of isolation and re-union in the course of time with respect to important sections of the Neotropical fauna must be incorporated now into any attempt at interpretation of the origin and composition of the present fauna of the region. It is possible that, for the invertebrates, this concept may be even more important than for the vertebrates. For information on this subject, see Haffer (1967), Vanzolini & Williams (1970), and Vuilleumier (1971).

The part of the Neotropical fauna whose origin and evolution is probably best known is the vertebrate fauna and, within it, the mammals. On account of their evolution in relatively recent times, of their generally large size, and of the facility with which their skeletal remains become fossilized, the paleontology of mammals is relatively well known, and make possible the most complete and coherent interpretations available of the origin and evolution of the Neotropical fauna.

Therefore, the facts related to the evolution of the Neotropical mammals and the interpretations of their present distribution cannot but influence the thinking of those who endeavour to understand the past history and the present distribution of other zoological groups. It is necessary to be wary, however, of the tendency of translating verbatim to other groups of animals -and particularly to invertebrates- knowledge obtained from the study of mammals. Mammals and insects have undoubtely different possibilities of migration and distribution, of survival or extinction under changing climatic conditions, etc. Also, insects are a much older group, and this should be kept in mind when we study the origin of regional faunas. Evolution in situ from very old stocks may be probable in regions where the presence of other animal groups may be attributable to migration.

Consensus of opinion indicates that, as in the case of the mammals, a primitive acridomorph stock already have existed during the Jurassic as an offshot of, or alongside, the predominantly Mesozoic Locustopsidae. Contemporarily with the primitive pantothere, triconodont, and other primitive mammals, there were eumastacids recorded from the Upper Jurassic of Asia (Sharov, 1968). But even if we put these primitive lines aside, it seems that the acridids, which are the dominant group of the recent acridomorph fauna must have evolved in the Cenozoic. Acrid evolution in the Neotropical region may have been influenced by the same geophysical, geomorphological, climatic, and other events that influenced the evolution and distribution of mammals.

It is relevant to this subject also to mention the rather widespread, incorrect notion that the main source -if not the only one- of the South American biota must be sought in the northern continents. A stream of life from the rich northern lands to the barren southern ones is supposed, by some authors, to be the origin at most of the southern biotas. I have been unable to find, however, a suitable explanation of why Laurasia might have been so rich in life, while the enormous Gondwanian continent should have been as poor as it has been postulated. The one factor that comes to mind is that scientific

thought has been unduly influenced by the far better knowledge of the fossil faunas of Eurasia and North America, as compared with those for the southern continents. Also, maybe the notion is valid for some well-known faunal groups and has been unduly extrapolated to include others. A reaction against the idea, mainly in the form of research in the paleontology of the southern lands, has fortunately set in, and it is likely the end result will be to prove that the idea a misconception, at least for many zoological groups.

The present paper is intended only as a preliminary hypothesis on the origin, evolution, and geographical distribution of the Neotropical acridomorph fauna. I believe the premises on which this hypothesis is based to be true and sound - [illegible]h as the classification of the Neotropical acridomorphs by Amedegnato, and also the [illegible]ormation on other subjects about which I lack the power of critical examination, such as those related to geophysics, paleogeography, paleontology, stratigraphy, etc. Unfortunately, the soundness of these premises does not guarantee the truth of my own ideas. Whatever is true in them, however, must come from the said premises, while I myself am responsible for the errors. I am aware that my interpretation of these things is highly speculative and that, in the best of cases, it will be modified in the future or discarded altogether. If it promotes further speculation and the study of this very interesting subject, it would have the right to claim some usefulness, even in case it proves to be entirely mistaken.

SOME FACTS ABOUT THE HISTORY OF THE NEOTROPICAL REGION.

The replacement in scientific thought of the concept of a permanent, unchanging relative position of the continents for an idea that admits the mobility of the land masses has a decisive bearing on the interpretation of the origin and history of the biota of the Neotropical region.

Until the middle sixties, and in spite of a growing tendency of the geophysical sciences toward the theory of continental drift, interpretations of the history of the Neotropical fauna were based on the premises of continental stability. Continents and oceans, it was assumed, had been practically where they stand now, at least during the time that incompasses the history of that fauna. Among the authors who have given the most cogent interpretations of the history of the Neotropical fauna, Simpson (1950-1965) and Darlington (1965) seem inclined to think that continental mobility is unnecessary for any explanation of the history of this fauna, and they discredit the idea of continental drift. At least in the case of Simpson, this comes from the circunstance that he deals mainly with the evolution of mammals during the Cenozoic, and during this era the intercontinental relations of the Americas were not too different from those of the present time. Also, it is fair to say that these excellent papers were written at a time when present concepts of continental drift and plate tectonics were in a state of preliminary research and discussion and were far from being generally accepted as they are today.

According to the recent geophysical data on continental drift, plate tectonics, paleomagnetism, sea floor spreading, etc., accumulated mainly during the last fifteen years, the movements of the continental masses from the end of the Paleozoic to the present have been ascertained with relative accuracy and cannot be ignored in any study of paleobiotas. Likewise, the knowledge of the geological history and paleontology of Central America and the northwestern corner of South America has been increasing steadily during the last two decades and now provides a fairly complete idea about the different stages of these regions throughout the Cenozoic and, hence, of the contacts and relationships between the Americas during the era.

The sources of this knowledge are, of course, many, and lacking expertise in these fields I have used for this paper mostly scientific compilations of information rather than the original papers themselves. In the text that follows, I do not make specific references to the source of each bit of information quoted, as I do later on with reference to the particular subject of the acridomorph fauna. The papers that have been used referring to geophysics, paleontology, evolution, geography, and geology are mainly those of Colbert (1955), Dewey (1972), Dietz & Holden (1970), Hallam (1972), Harrington (1962),

Hibbard (1960), Kurtén (1969), Laurentiaux (1953), Nygren (1950), Patterson & Pascual (1968), Raven & Axelrod (1975), Sauer (1950), Whitmore & Stewart (1965), Wilson (1963), and Woodring (1966). According to the information provided by these authors, I consider the following facts most significant in relation to the past history of the Neotropical acridomorphs.

At the beginning of the Mesozoic, in the Middle to Upper Triassic (200 million years ago), all the emergent lands that form the continents of the present time were united in a single supercontinent that has been called Pangaea (see figures 1 to 6 with reference to the text that follows). In that supercontinent, what is now South America was in direct contact with North America in the north, with Africa in the east, and with Antarctica in the south, and, indirectly, with the rest of the continental lands.

By this time, the evolution of the insects as a class was already fairly advanced. The world insect fauna was then composed of a mixture of primitive and relatively modern forms, some having originated in Laurasia, some in Gondwana. Except for the parts then covered by shallow continental seas, the possibilities of migration and territorial interchanging of these faunas must have been limited only by climatic and ecological conditions. There is no reason to suppose that the southern or Gondwanian insect fauna was then poorer than the northern or Laurasian one. The fossil record for the insects is such an incomplete and fragmentary one that the lack of fossil evidence cannot be taken as proof of the absence of a group of insects in a certain part of the world. The past history of insect faunas must necessarily be deducted in many cases from careful study of the recent ones.

Data on the sequence of events that took place after the beginning of the Mesozoic and resulted in the breakup of Pangaea and the subsequent drifting of the resulting continental land masses to their present positions are not completely in accord, and, as yet, it seems evident that some details remain obscure. In the summary of these events below, I have followed mainly Raven & Axelrod (1975) for the series of geophysical occurrences that influenced the faunal history of the Neotropical region.

The most important land connection of South America in regards to the oldest part of its biota must have been the connection with Africa, with which it was completely united before the appearance of the Atlantic Ocean. Because that connection was broken a long time ago (90 million years), however, relationships between the faunas of both continents must have been, by now, masked by a long period of separate and independent evolution and, in consequence, are difficult to trace at present. The past faunal continuity must be more significant in the case of the invertebrates, many of which were, by the end of the Paleozoic, much more highly evolved than most terrestrial vertebrates.

The Atlantic rift first appeared between the southern parts of South America and Africa some 140 million years ago, near the limit of the Upper Jurassic and the Lower Cretaceous. This rift widened in the south as it advanced northwards, and finally Africa

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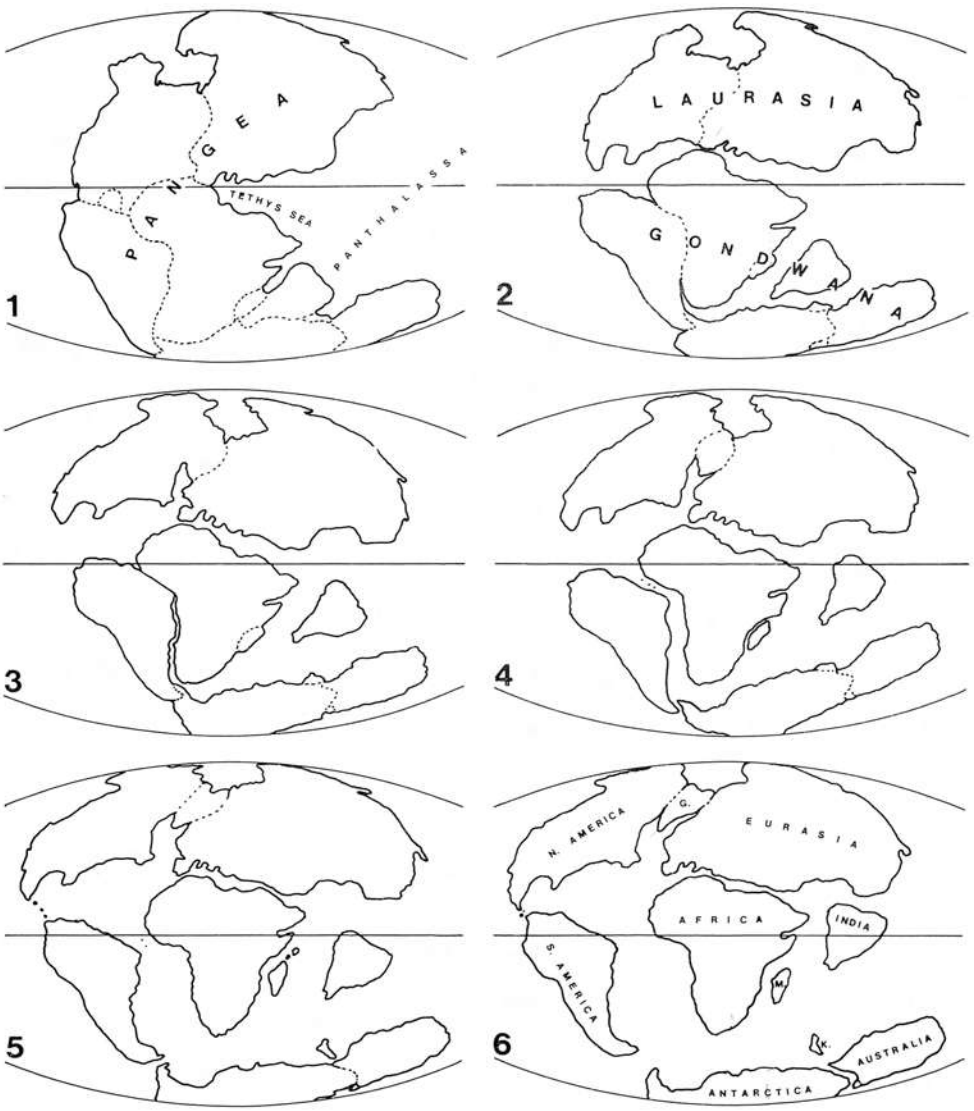
Fig. 1. Reconstruction of the supercontinent of Pangea as it may have been at the beginning of the Mesozoic, 200 million years ago. What is now South America was then directly united to North America, Africa and Antarctica, and through them to the rest of the emergent lands. Many faunal elements must then have been common to the three named continents, and other might have been widespread over all or most of Pangea, as it seems to be the case with the Locustopsidae, which are considered to be ancestral to all Acridomorpha. Fig. 2. Sometime between the end of the Jurassic and Lower Cretaceous, 150-140 million years ago, Laurasia in the north and Gondwana in the south became separated. Gondwana itself had already started to break up, with the drifting northwards of India, a rift between southern Africa and Antarctica, and the Atlantic Rift starting between the southern parts of Africa and South America. South America and Africa must have had many faunal elements in common at this time, when insects were already fairly evolved. Fig. 3. After the end of the Jurassic, 130 million years ago, the Atlantic rift had reached what is now the Gulf of Guinea, but South America and Africa were still united in the north. North America was then separated from the nearest point of South America by some 3000 kmts of open ocean. A periantarctic biota, whose relicts are still notable et present, must have flourished at this time. Fig. 4. Near the end of the Middle Cretaceous, 90 million years ago, South America began a long period of isolation from all other continental lands. The Atlantic Rift had already separated it from Africa, and direct land connections



with Antarctica were also broken. Many faunal groups that South America must have shared with Africa and with Antarctica + Australia began then a long period of separate and independent evolution in their respective territories, that must have by now made their primitive relationships difficult or impossible to trace. Fig. 5. At the close of the Cretaceous, 65 million years ago, South America was still an island. Africa was already some 600 kmts away at its nearest point. Between North and South America, the ocean had narrowed to 1300 kmts, and a chain of volcanic islands had appeared between then. From this time on, both continents drifted closer and islands must have become more abundant, making possible at some time a limited interchange of certain faunal elements which could traverse relatively short distances over the sea, either by flying, swimming or as waif immigrants. Fig. 6. In early to Middle Tertiary times, Africa and South America had drifted farther apart, but the latter had considerably approached North America, not only by drift but also by the emergence of lands in what is now Central America. Much later, near the close of the Pliocene (5,6 million years ago) a land connection between both continents was finally established, that was the corridor through which important faunal exchanges too, place.
(Figures 1 to 6, after Dietz and Holden, 1970, modified).

and South America became separated in the north (Guiana Shield) about 90 million years ago, near the end of the Middle Cretaceous. At the close of the Cretaceous, 65 million years ago, the shortest distance between S America and Africa (in the north) was around 600 kmts., and volcanic islands on and around the Mid Atlantic Ridge probably still formed a link between them.

Indirect connections of South America with Madagascar and India, through the African continent existed in the Paleozoic, and, of course, must have ceased with the separation of Africa and S. America. This connection may have been broken erlier if the separation of India and Madagascar from Africa took place before that of Africa with South America. Different authors do not agree in dating these events. Dietz & Holden state that India had already drifted wide of Africa + Madagascar by the end of the Triassic, while Raven & Axelrod say that they were still united in Middle Cretaceous. Madagascar was probably still united to Africa after the drifting away of India until about the end of the Cretaceous. The union of South America with Antarctica and Australia was a significant one from the viewpoint of the biota.

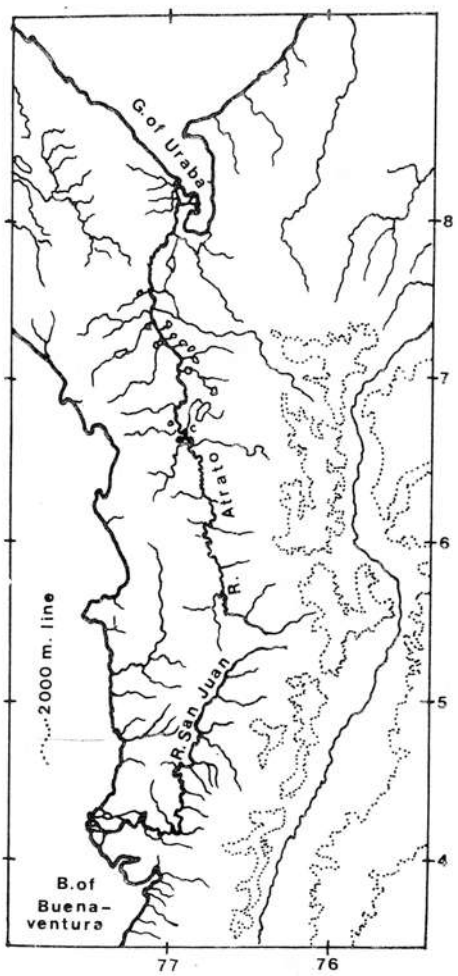


Fig. 7. The land bridge of Panama, that since Pliocene times communicates Central and South America. In the axis of the now emerged Bolivar Geosyncline, covered by the sea until Mid-Pliocene, flow the Atrato and San Juan Rivers, in the rainiest part of South America. The only overland route between them is the narrow passageway by the headwaters of both rivers, roughly midway between parallels 5 and 6. (After Hershkovitz, 1966).

A close relationship between elements of southern South America and the Australian-Tasmanian and even the New Guinean and New Zealandian faunas is evident and has been the subject of much research. At the time of union with South America, Antarctica was located north of its present position. Its northern edge, at least, then had a temperate climate, as the study of its fossils has shown. Its role as a passageway to and from Australia and other eastern lands must therefore, have been important even if only faunae of temperate climates could pass through it. The break between northern Antarctica and the southern end of South America probably took place before the end of the Cretaceous, some 85 million years ago, but these lands remained in close proximity for a long time afterwards, and indirect connection through islands (finally broken by distance and cold) persisted until about the end of the Eocene, 38 million years ago. Regarding the overland connections of South America with other continents, the one with Africa was broken about 90 million years ago; that with Antarctica maybe a little later, 85 million years ago. Thus, South America was an island continent for about 80 million years, until a new land connection with N. America, the Panamanian Land Bridge, was established approximately 5,6 million years ago.

In regard to the relationships between North America and South America, the following events are of importance. A wide union of the continents in what is now the Caribbean region existed since some undetermined time in the Paleozoic, and lasted until the breakup of Pangaea. Details of that union in what is now the Gulf of Mexico and the Caribbean Sea are, however, obscure. The connection probably broke at the close of the Triassic, some 190 million years ago, and, from that moment, the continents drifted rather rapidly apart. Separation of North and South America was probably roughly coincident with the drifting apart of the whole of Laurasia from Gondwana, which remained separated until relatively recent times. Separation of North and South America reached a maximum of 3000 kms. during Middle to Upper Cretaceous. This distance was wider than the shortest present distance between Africa and South America.

Toward the end of the Cretaceous (approximately 65 million years ago), South America and North America were still separated by some 1300 kms. of ocean, though there probably existed a chain of volcanic islands between them that became more numerous in the course of the Tertiary. Probably after the close of the Cretaceous, what are now the northern and middle parts of Central America began to emerge from the waters that covered them before. The distance between North and South America gradually diminished, and the number of intervening islands increased until actual contact between both continents took place in Middle to Upper Pliocene, some 5,7 million years ago. Also in the Pliocene, the rising of the Andean Chain began. First proximity and later actual contact between the Americas at the Isthmus of Panama, and also the rising of the Andes, are elements of importance for the history of the Neotropical biota.

With regard to the actual union of the two continents, the geophysical, paleogeographical, stratigraphic, and paleontological data seem at present to indicate:

a) North and South America were widely separated during most or all of the Cretaceous (70 million years). Hence, the possibilities of migration of animals from one to the other of these continents during Cretaceous times were, in the best of cases, slight. The Atlantic and Gulf coastal plains of North America, including Florida, were under water until the Oligocene, making the gap between the continents even greater.

b) By the beginning of the Tertiary (65 million years ago), 1300 kms. of open ocean still separated the southern end of North America (what is now northern Nicaragua) from the northwestern coast of Colombia. Emergence of lands that took place at the close of the Cretaceous had formed the northern part of Central America, but the rest of it was still under water. Additional land emerged during the Tertiary forming part of Panama, which was just a peninsula of the North American continent until Mid-Pliocene.

c) Stratigraphic and paleontologic studies reveal that the north western corner of Colombia was constantly covered by water from the Upper Jurassic to the Paleocene. Between the Eocene and Lower Oligocene, the opening of the Bolivar Geosyncline was the last obstacle for the union of Panama and Colombia. The botom of this geosyncline did not completely emerge until Mid-Pliocene, when a direct land connection between

North and South America was finally established. Earlier connections have been postulated, but stratigraphic and paleontological data make them improbable. The differences of the Miocene mammal faunas of southern Panama (fossil beds of Cucaracha) and northern South America (La Venta and other localities) are very clear, the Panamanian fauna being composed exclusively of nearctic mammals, while those of the Colombian and other northern South American localities consist only of South American ones. Likewise, the Miocene marine mollusks in the Caribbean and Pacific sides of Panama are identical, showing that these waters had not yet became separated by a barrier of land.

Another important fact regarding the neotropical fauna was actual contact between North America and Asia in the region of today's Bering sea that existed for most of the Cenozoic. The climate of this region during at least part of the Cenozoic was much milder than nowadays (Hibbard, 1960). Several well documented migration of mammals took place over this land bridge, and the same occurred with other faunal elements.

The possibilities of faunal migration between continents are not limited to and do not necessarily coincide with periods of actual contact between them, as it has been repeatedly pointed out by zoogeographers. Many animals are able to cross extensions of water, either by swimming, flying, or in a passive way on floating plant rafts, driftwood, or other floating debris. The mere proximity of lands and the presence of intervening islands greatly increase the chances of migration. An actual land bridge may prove impassable to many animals because of adverse climatic or ecological conditions. Deserts, high mountain chains, or intense cold are effective barriers in most cases, on spite of land continuity. Even in cases far rwoved from these extremes, the conditions of climate and vegetation prevalent in the regions of communication between continents -such as the Cenozoic Bering bridge or the Pleistocene to Recent one of Central America- may have the effect of a filter, making difficult or impossible the passage of organisms that are unable to adapt to or withstand, even temporarily, the climatic and ecological conditions in the corridor.

With regard to the possibilities of migration to or from South America and the neighboring lands, the circumstances referred to above seem to indicate the following:

a) Opportunities for migration between South America and Antarctica -or Australia via Antarctica-were direct overland until Upper Cretaceous, 85 million years ago. Indirectly through island chains, limited possibilities of migration probably existed until the beginning of the Oligocene, 38 million years ago.

b) Direct land connections between North and South America existed from an undetermined age in the Paleozoic until the close of the Triassic, approximately 190 million years ago. These continents drifted apart more or less rapidly in the Jurassic, and during the whole of the Cretaceous some 3000 kms. of sea extended between them. As has been noted, the possibilities of animal migration between them increased during the Tertiary as the two continents came closer by drift, by the emergence of lands in southern North America, and by the formation of chains of volcanic islands between them until direct contact was established in the Pliocene, , 5,6 million years ago.

c) Direct overland migration of faunae to and from the northeastern part of Asia and North America by the Bering bridge existed probably for a good part of the Cenozoic. Faunal interchange between Asia and South America by this route certainly took place in late Cenozoic.

d) Even if it may be inferred that the most important connection of the South American continent with regard to faunal migrations in relatively modern times was the Central American bridge, in the older strata and the so-called autochthonous elements it is necessary to consider also the Gondwanic fauna of the Paleozoic and Mesozoic eras, and the continuity of lands of this enormous continent that made possible the migration of faunas between its different regions.

e) Doubtless, the establishment of a direct overland connection between North and South America in the Pliocene allowed for important faunistic interchange between the continents, as has been clearly shown, especially by the study of the mammal faunas. However, the humid tropical conditions prevalent in Central America are an important barrier for animals of temperate regions. Even now, direct terrestrial route between

Central America and northwestern Colombia presents insurmountable difficulties for many animals. The Pacific coast of Colombia, with 6000 to 8000 millimeters of yearly rainfall, is probably the rainiest region of South America. Parallel to this coast runs the axis of the ancient Bolivar Geosyncline, occupied by the basins of two important rivers always full to overflow by torrential rains: the Atrato River flowing to the north, going to the Bay of Urabá, in the Caribbean Sea, and the San Juan River going south to the Pacific coast north of the Bay of Buenaventura (Fig. 7). The only passageway between the two basins is a narrow strip of land by the headwaters of both rivers. It is difficult to imagine animals of dry or temperate climate successfully migrating through this kind of land. However, some have done it, such as the acridomorphs of some groups that will be mentioned below (particularly the Melanoplinae and the Oedipodinae). A plausible explanation is that, during the Pleistocene glaciations, the climate of this region may have been far more favorable for the migration of such animals than it is at present.

ORIGIN AND EVOLUTION OF THE ACRIDOMORPHA

After the above sketch of the principal external elements that are important for understanding the origin and evolution of the Neotropical acridomorphs, especially the South American ones, it is convenient to examine the scanty available knowledge on the origin and evolution of these insects in general. The fossil specimens that have been found to date are few, and what is known about their evolution is more the result of deductions and comparisons of recent forms among themselves and with the few fossil ones than the outcome of a direct study of their fossil record.

The origin of the Acridomorpha seems certainly related to the Mesozoic family Locustopsidae. Sharov (1968) considers the Locustopsidae as the direct ascendants of the Caelifera (Fig. 8). The Locustopsidae appear in the fossil record in the Lower Triassic and are found throughout the Triassic, Jurassic, and Lower Cretaceous, to disappear at the close of the Middle Cretaceous. According to Sharov (loc. cit.), fossil Locustopsidae are found in the Triassic and Jurassic of Siberia, in the Jurassic of western Europe, and also in the Upper Jurassic of Australia. If we consider the shape of Pangaea during the Jurassic (Fig. 1), Siberia and Australia were then the regions fartherest apart of the supercontinen by an overland route. A wide portion of the Panthalassa and all of the Tethys Sea interposed between them. This suggests that the known fossil record of the locustopsids must be fragmentary, and that they must have had a much larger distribution, probably being widespread over most of Pangaea, or at least over the territory along its oriental coast. The mentioned author indicates that some locustopsids already show acridoid characters in the structure of the tarsi, antennae, and ovipositor. Some Cretaceous species also approach the acridoids in the structure of the hind wings. This leads him to consider the locustopsids as the origin of all the acridomorphs and of the Caelifera in general.

Also according to Sharov, the Eumastacidae arose from the Locustopsidae in the Lower Jurassic; the basic stock of all the Acridoidea evolved at the limit of the Lower and Middle Jurassic; and the Pneumoridae and possibly the Proscopiidae (families that this author considers to be related) originated in the Middle Cretaceous near the extinction of the locustopsid stock (Fig. 8). The basic stock of all the Acridoidea *sensu stricto* (exclusive of Eumastacidae, Proscopiidae, and Pneumoridae) would be, according to this author, of Jurassic origin, but the diversification and expansion of these insects did not take place until the Tertiary, simultaneously with the appearance of prairies and further increased by Mid-Oligocene with the spread and develpment of steppe and semidesert. Fossils of acridoids are known from the Oligocene, represented by species not too different from Recent ones.

Ragge (1955) deducts, on the basis of the study of wing venation, that the locustopsids and the acridomorphs must be related by common origin rather than by direct descent. According to his opinion the Locustopsidae, Pneumoridae, Eumastacidae,

and Acrididae arose at the end of the Paleozoic from an unknown, primitive ancestral stock. The probably Pangeic distribution of the Locustopsidae does not help to clarify this problem whether we consider the locustopsids as direct predecessors of the acridomorphs or as a parallel line of common ancestry.

The presence in South America of certain relatively primitive acridomorph groups such as the Proscopiidae and the Tristiridae that do not exist in other regions of the world seem to be indicates that at least a part of the primitive stock of acridomorphs was already in Gondwana when it separated from Laurasia at the end of the Triassic. It may also be possible that the Acridomorpha are to some extent polyphyletic, and that several of the Recent groups come from slightly different branches of an older pre-acridomorph stock, related in some way to the Mesozoic locustopsids. Recent classifications of the Caelifera such as that of Uvarov (1966), which separates the Eumastacidae, Proscopiidae, Tanaoceridae, and Pneumoridae from the superfamily Acridoidea, or that of Dirsh (1975), that erects the Eumastacoidea (Eumastacidae + Trigonopterygidae + Proscopiidae) as an order separate from the Acridomorphoidea within the superorder Orthopteroidea, suggest a certain plurality of origins at least for these cases. Within the South American fauna, the Proscopiidae, Tristiridae, and the combined Ommexechidae + Romaleidae could be the descendants of three different branches of primitive Gondwanian acridomorph or pre-acridomorph stock.

RECENT ACRIDOMORPHS OF THE NEOTROPICAL REGION

The composition of the Recent fauna of Acridomorphs in the Neotropical region indicating families and, in the case of the family Acrididae, also subfamilies, is shown in Table Nº 1. This table is not arranged according to phylogeny or affinities, but rather in relation to ideas on the origin of the differente groups that will be referred to in the text that follows. For each of the families and subfamilies, the approximate number of Neotropical genera has been indicated except in the case of the Romaleidae, in which the total number of the American genera is included. The cassification used in this table is, in general, according to Amedegnato (1974), with some slight modifications, notably the inclusion of the genera of the Aucacrini with the Ommexechidae, rather than with the Romaleidae. The names of families that are not found outside the Neotropical region (except for a few genera that have invaded the south of the Nearctic region) have been marked with an asterisk (+). In the case of the family Acrididae, the same applies to the names of the subfamilies.

Examination of this table shows that, of the eight families found within the Neotropical region, three (Eumastacidae, Pyrgomorphidae, and Acrididae) are shared with the rest of the world. The other five (Proscopiidae, Tristiridae, Ommexechidae, Romaleidae, and Pauliniidae) are exclusively Neotropical and probably of South American origin, and as such, have been marked with an asterisk. The family Acrididae as a whole is, of course, represented elsewhere in the world, but within it there are two different groups of subfamilies. The first of these groups comprises five subfamilies that have been marked with an asterisk (Proctolabinae, Copiocerinae, Leptysminae, Rhytidochrotinae, and Ommatolampinae) because they are not represented outside of the Neotropical region (except for a few genera in the south of the Nearctic region). If they are outsiders to the Neotropical region, as their acridid relationships could indicate, they must come from very old immigrants, and a considerable part of their evolution must have taken place in the Americas. The remaining five subfamilies (Melanoplinae, Cyrtacanthacridinae, Acridinae, Gomphocerinae, and Oedipodinae) are represented elsewpere in the world, and must be rather recent additions to the Neotropical fauna. Each family and, in the case of the Acrididae, each of the different subfamilies pose peculiar problems, as will be shown below.

Table Nº 1. Composition of the Neotropical acridomorph fauna, indicating for each family or subfamily the number of known Neotropical genera. Nearctic genera have also been included in the case of the Romaleidae. Classification slightly modified after Amedegnato (1974).

Families and subfamilies	Number of genera included in each
PROSCOPIIDAE+	17
TRISTIRIDAE+	17
OMMEXECHIDAE+	13
ROMALEIDAE+	63
PAULINIIDAE+	2
EUMASTACIDAE	20
PYRGOMORPHIDAE	5
ACRIDIDAE	191
PROCTOLABINAE+	22
COPIOCERINAE+	11
LEPTYSMINAE+	22
RHYTIDOCHRTINAE+	15
OMMATOLAMPINAE+	46
MELANOPLINAE	22
CYRTACANTHACRIDINAE	2
ACRIDINAE	14
GOMPHOCERINAE	30
OEDIPODINAE	7

AUTOCHTHONOUS NEOTROPICAL FAMILIES OF SOUTH AMERICAN ORIGIN
(Proscopiidae, Tristiridae, Ommexechidae, Romaleidae, Pauliniidae)

According to their distribution whithin the Neotropical region, this assemblage of families seems, to be strictly of South American origin. Most of them originated near the southern end of South America. Among them the family Romaleidae, with 63 known American genera, is the largest and most diversified. The Proscopiidae is distributed throughout South America and is practically limited to this continent. The Tristiridae, with 17 genera, is clearly of southern South American origin. The Ommexechidae, with 13 genera, is also of South American distribution, and the Pauliniidae is a very small, probably artificial family of doubtful affinities.

Proscopiidae. This typical South American family is aberrant with regard to the rest of the Acridomorpha, which has lead most authors to separate it from the true Acridoidea. Mello Leitao (1939) points out certain similarities of the proscopiids with the Neotropical pyrgomorphid genera *Omura* and *Algete* but does not suggest further affinities between them, which would be, of course, unwarranted.

A close relationship between proscopiids and eumastacids has been repeatedly suggested. Westwood in his "Arcana Entomologica" (1843, vol. I, p. 99; vol. II, p. 54), was probably the first to indicate a relationship between *"Mastax"* and *"Proscopia"*. This opinion of Westwood has not been quoted afterwards, to my knowledge, but the same relationship has been indicated by several later authors. C. Bolivar (1930) says that "the eumastacids, together with the proscopiids and the pneumorids, form a natural group within the Acridoidea, because of the lack of abdominal auditory organs, and the shortened antennae". Rehn (1952) suggest a relationship betwean the proscopiids and the eumastacid subfamily Morabinae. Dirsh (1961) indicates that the proscopiids do not have a close relationship with the other families of acridoids, and suggests that they represent an early branch of an unknown pre-acridoid stock, with remote affinities with the eumastacids. Randell (1963) points out similarities between the female reproductive structures of proscopiids and eumastacids.

Recently, Blackith & Blackith (196) presented a table comparing the external characters of the Morabinae with those of the proscopiids, pyrgomorphids, and acridids, pointing to a marked similarity of the first two groups. Kevan (196) formally erected the superfamily Eumastacoidea with the families Eumastacidae and Procopiidae. Dirsh (1973) erects the order Eumastacoidea with the eumastacids and proscopiids and also the locustopsids and trygonopterigids. Sharov (1968) places the proscopiids and pneumorids together in his superfamily Pneumoroidea.

It seems evident from the above that a majority of the opinions relates the proscopiids and eumastacids, mainly through the eumastacid subfamily Morabinae. Descamps (1974), however, from a study of the genitalia of nine genera of proscopiids and their comparison with that of the majority of the genera of Eumastacidae, concludes that the two groups are unrelated, and that different and independent superfamilies should be erected for them. This latter author remarks that the proscopiids, an autochthonous South American group, could not be related to the South American eumastacids, which are recent invaders of Oriental affinities. He also denies for them, on the basis of their genitalic structures, any relationship with the Australian Morabinae.

The phyletic origin and relationships of the Proscopiidae cannot yet be clearly defined with the available information. It is evident that the proscopiids are an ancient group with little affinity with the rest of the acridomorphs. Their geographic origin lies in the southern part of South America, and from there they have spread to the rest of this continent, with one species reaching Central America (Panama and Costa Rica) and another the island of Bonaire. Liana (1972), who accepts their relationship with the Morabinae, proposes for both groups a common paleoantarctic origin. If a relationship with the Morabinae does not exist, as Descamps states, the proscopiids probably descended from a primitive acridomorph stock isolated since the beginning of the Mesozoic in the southern part of South America.

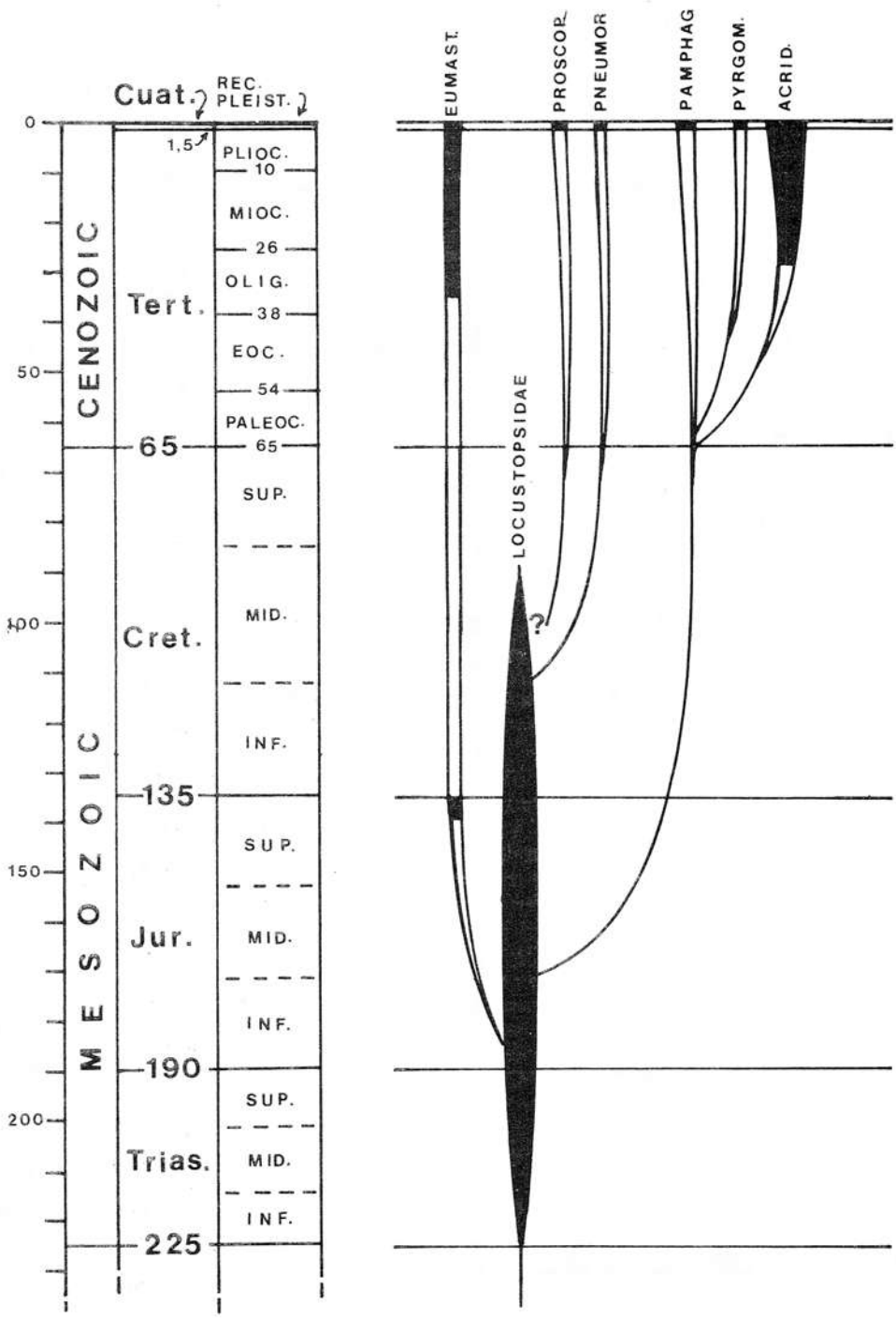


Fig. 8. Phylogeny of the Acridomorpha (After Sharov, 1968). The Locustopsidae are shown as the basic stock of all recent acridomorph groups. Numbers represent millions of years to the present.

Tristiridae. This family was first defined by Rehn (1942) and later in a more comprehensive way by Amedegnato (1974). It is evidently of South American origin. In the mentioned paper by Amedegnato, it is evident that, by a typographical error, two pyrgomorphid genera, *Algete* and *Deraspiella* are repeated at the beginning of the list of tristirids genera, while *Bufonacris, Chilacris,* and *Crites* have been omitted. Our own studies agree with Amedegnato's opinion in assigning to this group the rank of family.

The geographical origin and dispersion center of the Tristiridae is located in the southern part of South America (Patagonia and south Chile), where there exists at present the greatest concentration of genera and species. Having their origin in a temperate to cold climate, these insects have been able to migrate north only through the highlands of the Andes, reaching Peru (and maybe Ecuador) through the restricted regions of favorable climate. Rehn (loc. cit.) thinks that the tristirids are an ancient group, and says that the beginning of their evolution must antedate the start of the Andean orogenesis (that is, pre-Pliocene).

The tristirids as a group are probably much older than that. Even if the evidence of phyletic relationships of this group with other acridomorphs is still obscure, it seems plausible that, as in the case of the proscopiids, the tristirids may come from a primitive acridomorph stock located in South America since early mesozoic times.

Pauliniidae. Little can be said about this family, to which only two genera *(Paulinia)* and *Marellia)* have been assigned. Study of the genitalia of these two genera creates doubts about their close relationship. *Paulinia* seems, so far, to be monotypic, and a number of species have been assigned to *Marellia,* though these species are difficult to separate. The external similarity of these two genera may be due to convergence by adaptation to the aquatic habitat. Both have much the same distribution in tropical and subtropical South America. The pauliniids might be related to the Acrididae.

Romaleidae. Of the group of autochtronous South American families, the romaleids, with 63 genera, represent the largest and most diversified family. The great adaptive radiation of the romaleids is shown by their invasion of diverse habitats ranging from xerophilous, semi-arid conditions *(Alcamenes),* to the dendrophilous forms of the tropical rain forest *(Trybliophorus, Nautia, Ophthalmolampis).* I consider this family as it has been defined by Amedegnato (1974), with the exception of the tribe Aucacrini, that I include with the Ommexechidae. The Aucacrini seem to be a sort of bridge between the two families. Roberts (1941), when erecting the subfamily Romaleinae, indicated that it was probably of ancient origin.

Judging by its distribution and affinity with the Ommexechidae, the Romaleidae seem to have their geographical origin in the southern temperate and subtropical zone. From an evolutionary viewpoint, they have been more successful than the Ommexechidae, and a number of the genera have adapted very well to the tropical jungle, and have spread through the Amazon basin and the Guiana Shield. Probably after the establishment of the Panamanian bridge or maybe before, through island chains, they invaded Central America, Mexico, and the southern part of the Nearctic region *(Brachystola, Dracotettix, Litoscirtus, Phrynotettix, Romalea, Taeniopoda, Tytthotyle).* Such generic diversification in the Neartic region suggests an early invasion of the North American continent.

Ommexechidae. The composition of this family has been the subject of controversy, especially regarding some groups which differ in structure from *Ommexecha* and closely related genera. I agree with the composition proposed by Eades (1961), including in this family all the genera now listed by Amedegnato (1964) plus the tribe Aucacrini which she puts in Romaleidae (excepting *Quitus,* which I believe not to be a valid genus, being based in a unidentifiable nymph). Mesa (1963) gives reasons derived from caryology and phallic characters for assigning family rank to the ommexechids.

Roberts (1941), Eades (1961), and Amedegnato (1974) state that the Ommexechidae and the Romaleidae are closely related, and the first of these authors also indicates that the Ommexechidae are the most divergent branch of the Cryptosacci. Ronderos (1972, 1973a,b,c, 1974) in the course of an excellent revision of this family, also adopts the composition and classification of this family proposed by Eades (1961).

The Ommexechidae are autochthonous South American acridoids. Their origin and distribution center is located in the southern temperate to subtropical zone (middle and northern Argentina, Uruguay, Paraguay, southern Brazil). A few species reach north, invading the tropics. Members of *Ommexecha* and the monotypic genus *Descampsacris* are found in the Amazon basin and north of it, at least in Colombia.

FAMILIES BELONGING TO THE WORLD FAUNA OF ACRIDOMORPHA

The three families that follow (Eumastacidae, Pyrgomorphidae, and Acrididae) are world-wide in distribution. This sets them apart from the preceding ones, that not only are exclusively Neotropical (with the exception of Romaleidae, that has invaded the south of the Nearctic region), but also seem to be autochthonous to South America. The members of these three families can be separated into two clear-cut groups according to their apparent origin. The first of these groups includes the Eumastacidae, the Pyrgomorphidae, and five subfamilies of Acrididae: Melanoplinae, Cyrtacanthacridinae, Acridinae, Gomphocerinae, and Oedipodinae. All these families and subfamilies, while forming a systematically heterogeneous group, share the common character of being outsiders of either Neartic or Old World affinities, which invaded the Neotropical region probably during the Cenozoic and South America in late Cenozoic times.

The second, taxonomically more homogeneous, of these groups includes the remaining five subfamilies of Acrididae (Proctolabinae, Copiocerinae, Leyptysminae, Rhytidochrotinae, and Ommatolampinae). This group differs from the preceding one in that all of its members are typically Neotropical. Some have stray representatives in the southern part of this region, neither have they been found anywhere in the Old World. All of them are prevalently tropical and, according to their particular distribution, their centers of evolution must have been either in Central America or northern South America (Guiana Shield), whence most of them have spread into the Amazon basin. A brief discussion of each of these families and subfamilies follows.

Eumastacidae (sensu lato). The great antiquity of the Eumastacidae has already been mentioned. They diverge considerably from the rest of the acridomorphs, as has been shown by Sharov and other authors.

Ragge (1955) thinks that, in the Upper Paleozoic, some 225 million years ago, the eumastacids were already differentiated as a line that diverged from the rest of the Caelifera. According to Sharov (1968), these insects arose from the Locustopsidae during the Lower Jurassic, and he describes a new genus *(Archaeomastax)* from the Upper Jurassic of Kara Tau (U.S.S.R., east of the Aral Sea) that would be the oldest known acridomorph belonging to a recent group. Apart from this genus, fossil Eumastacidae are not known until the Pliocene. In North America, fossil eumastacids have been found in the Oligocene of British Columbia and in the Miocene of Florissant, Colorado (Rehn, 1948).

The great antiquity of the eumastacids seems to be beyond doubt. Blackith (1973) gives additional proof of this antiquity, such as the frequent association of eumastacids and Pteridophyta (ferns), on which many species live and feed, and he lists several primitive anatomical characters. According to this author, a Paleo-Mesozoic origin of the eumastacids is necessary to explain their present distribution on the basis of a pangeic origin, possibly in the Africa+Madagascar+India general area. Also according to this author, multivariant analysis of the characters of recent groups and also cytological studies support the notion of great antiquity of this group. Descamps (1973a,b) agrees, and he makes additional contributions in support of it. He points out the great diversity of the structures of the abdominal terminalia and the genitalia, which make necessary a division of the family into several different groups, which suggests a long evolution.

Once the antiquity and corresponding diversity of the eumastacids is established, the question remains of when and how they reached the Neotropical region. Descamps (1973b) reaches the conclusion that the American Eumastacidae *(sensu lato)* are related

to those of the Oriental region, and must have invaded America from Eastern Asia in the Mesozoic (through the Bering Bridge, according to his map). Two different groups from the said region invaded America: first the ancestors of the Cryptophalli, and later those of the Stenophalli. These early eumastacids settled in the Caribbean region, which became a secondary evolution center for them. The invasion of South America must have occurred (Descamps, loc. cit.) during the Cretaceous (probably near its end, through island chains?) on two successive occasions: first came the Morseinae and Temnomastacinae, which are the subfamilies which now reach farthest south, and then the rest of the subfamilies, that remain to this day circumscribed to northern South America and the Amazon basin (besides Central America).

The already mentioned findings of a fossil Oligocene eumastacid in British Columbia, and of a Miocene one in Florissant, Colorado, support the idea of an invasion from Asia, via Bering.

Pyrgomorphidae. Among the Acridoidea *(s.str.)*, the family Pyrgomorphidae seems to be one of the oldest. According to Sharov (1968), the Pyrgomorphidae and Acrididae arose from pamphagid stock at the beginning of the Cenozoic ((fig. 8). Dirsh (1975) attributes great antiquity to pyrgomorphids, suggesting that these insects originated at an early age from pre-acridid stock. Rehn (1951) also indicates that pyrgomorphids belong to an ancient line of acridoids.

Concerning the geographical origin of the pyrgomorphids, Rehn (1951, 1953) points to Gondwana as the most probable place, and remarks that the area Africa+Madagascar is the richest in species, and that the Oriental region stands second to it. Kevan (1964, 1965) points to the pan-tropical distribution of these insects and indicates that the Ethiopian region plus Madagascar is the richest in genera and species and hence could be their main evolution center, but also remarks that the greatest number of tribes are represented in the south Asiatic region, and that the origin of the family could, for this reason, be Oriental as well. If the origin of the pyrgomorphids were Upper Triassic, before the breakup of Pangaea, a duality of evolutionary centers would be unnecessary for explaining their present distribution since the origin of the pyrgomorphids could be located within the territory that enclosed the then united oriental Africa, Madagascar, and India.

In the Americas the Pyrgomorphids are located mainly in Mexico, Central America, and northern South America, with ten genera in Mexico + Central America, and five in South America (Kevan 1964). Also according to Kevan (1964, 1965), the American pyrgomorphids show affinities with those of southeastern Asia, and must have reached America from there (through the Bering bridge) in two or three separate invasions.

In this way, American pyrgomorphids would be, like the American eumastacids, invaders from S.E. Asia. Their very limited success in South America (only five genera) points to a rather recent (Pleistocene) invasion of this continent.

Acrididae. The family Acrididae presents a peculiar case. Of the ten subfamilies represented within the Neotropical region, there are four (Melanoplinae, Acridinae, Gomphocerinae, and Oedipodinae) wich are clearly late invaders from the Nearctic region, with connections with the rest of the Holarctic region and Old World fauna in general. Another of its subfamilies, the Cyrtacanthacridinae, is prevalently an Old World group, with ethiopic and pan tropical relationships. The five remaining subfamilies (Proctolabinae, Copiocerinae, Leptysminae, Rhytidochrotinae, and Ommatolampinae) are exclusively neotropical, but their centers of evolution and distribution are located in Central America and the northern part of South America. From there, some of them spread to the south of the Nearctic region and the West Indies, most of them to the Amazon basin, and a few even to the south temperate zone of South America. The fact that all these subfamilies belong to the family Acrididae which is of world-wide distribution, together with their north-neotropical location, seems to indicate for them a relatively ancient origin and migration from an unknown part of the world. Their present habitat also suggests that, whatever the place they came from, it must have had a tropical climate, since they are prevalently tropical. A few remarks on each of the acridid subfamilies follow.

Proctolabinae. According to the recent paper by Descamps (1976) this subfamily, with 22 known genera, has a Central American and Amazonian distribution. Ten of its

genera are of Central American distribution (reaching southern Mexico); another ten are Amazonian and the remaining two inhabit both regions. Only one of the Amazonian genera reaches south as far as Mato Grosso and Paraguay. According to this author, most of the Central American genera are rather primitive, while the Amazonian ones are on the whole, more evolved.

Copiocerinae. Most of this subfamily (tribe Copiocerini) is northern South American and Amazonian, with two genera *(Adimantus, Chlorohipus)* reaching the southern subtropical zone. The other tribe, Aleuini, has a peculiar distribution, with most of its species (genera *Aleuas* and *Zygoclistron*) in the southern subtropical to temperate zone, and a single known species of *Zygoclistron* north of the Amazon River at Mount Roraima.

Leptysminae. This subfamily has an ample distribution within the Neotropical region, and has spread northward to the south of the Nearctic region *(Leptysma).* Its tribe Leptysmini is the most widely distributed, extending from Uruguay and corresponding latitudes of Argentina to southern United States. The Chloropseustini is typically Amazonian and the Tetrataeniini goes all the way from southern Mexico and Central America to the south of the Amazonian basin, with at least one genus *(Haroldgrantia)* reaching the southern temperate zone in Uruguay and Argentina.

Rhytidochrotinae. Most of its 15 genera are from northern South America *(Colombia),* with one of them reaching north to Central America *(Piezops),* one to Ecuador *(Paropaon),* one to Peru *(Rhytidochrota),* and one even to Central Brazil *(Lathacris).* Its center of evolution is northern South America.

Ommatolampinae. With 46 known genera, this subfamily is considerably larger than any of the preceding ones. It reaches north to the southern U.S.A. *(Clematodes)* and south to Uruguay and corresponding latitudes of Argentina *(Abracris).* It has also invaded the West Indies *(Dellia, Caletes).* Most of its genera, however, are located in northern South America and the Amazon basin, and some of them are Central American.

Cyrtacanthacridinae. This subfamily presents peculiarities that set it apart from the rest of the Neotropical acridids. As a whole, it has some 30 genera distributed throughout the tropics and subtropics of the world. In the Americas it is represented only by *Halmenus,* in the Galapagos Islands, and *Schistocerca,* with a number of species throughout the tropical and subtropical parts of the Americas. *Schistocerca* also has a single species in Africa.

This distribution is difficult to explain within our present knowledge. Judging only by the genus *Schistocerca* it would seem that it is of South American origin, and that a single species reached Africa and became established there. The fact that the large majority of the cyrtacanthacridines belong to the Old World fauna seems to invalidate this explanation. As a provisional hypothesis at least, it could be proposed that the genus *Schistocerca* was originally African, and that the common ancestor of the African and American species reached the Americas in some undetermined age. This hypothetical *Schistocerca* found in America favorable conditions that lead to considerable speciation, while its African counterpart was severely limited in its possibilities by the other cyrtacanthacridine genera and species that already occupied all the favorable niches. Even if among the species of *Schistocerca* are some of the best fliers of all the acridids, how and when this hypothetical ancestor of the American species reached the New World is a matter for further speculation.

Melanoplinae. According to Rehn & Randell (1963), the melanoplines are of Neartic origin, and its primary center of distribution is Laurentian. From there they spread to the palearctic (via the Bering bridge) and the Neotropical regions, reaching South America through the Panamanian land bridge. The Neotropical melanoplines are certainly invaders from the north, and, among them, the South American ones would be post-Pliocene migrants.

By reason of their origin in a region of temperate climate, these insects invaded South America through the highlands of the Andes, thus avoiding tropical conditions, and only were able to leave these high-lands when they reached the subtropical and temperate zone in the south of the continent. There they underwent a considerable adaptive radiation (Rehn, 1954; Carbonell & Ronderos, 1973; Rowell & Carbonell, 1977). According to Rehn (1954), the two secondary centers of evolution of the melanoplines

on the South American continent are in the Colombian-Venezuelan Andes and in that region of South America south of the 15th. parallel to south central Argentina and Chile.

The melanoplines, with more than 20 known Neotropical genera, are at present an important faunal element in this region, especially throughout the Andes and in the southern part of South America. With one known exception, they have been unable to colonize the humid tropical jungle. They stop in the marginal and transitional regions. The Neotropical melanoplines are currently being revised by Ronderos and by Ronderos & Carbonell.

Acridinae. Also recent invaders from the Neartic region, the Neotropical acridines have spread with moderate success to South America, where they probably arrived during the post-Miocene. The Neotropical elements of this subfamily have not been the subject of any recent revisionary study that would throw light on their affinities and possible relationships with other acridines of the world. Coming from the Nearctic region, they must be related in some way to the Old World acridine fauna. It is interesting to note that one of its species, *Metaleptea brevicornis* (L.) is the only known acridomorph that reaches all the way from Canada to Argentina and Uruguay.

Gomphocerinae. As in the preceding case, the Neotropical gomphocerines seem to be Neartic invaders. The South American ones probably came through Panama after the union of the continents. Some 30 genera are known from the Neotropical region. In a recent study of the Gomphocerinae of the world, Jago (1971) analyzes the relationships of the different genera. According to his study, the Neotropical gomphocerines seem to be related to the Asian species through the Nearctic fauna. This suggests a rather recent (Cenozoic) distribution of Eastern Asia - Bering - North America - Central America - South America pattern. A few cases of apparent neotropical ethiopic relationship are mentioned, which could be relicts of a larger distribution via Europe or Asia, rather than an indication of direct relationship with the Neotropical and Ethiopian faunas, which seems unlikely for modern acridids of this group. An interesting case is that of *Dichromorpha.* This genus has the species *D. viridis* in North America and the similar *D. australis* in southern South America, separated by an enormous expanse of territory where 17 has never been found.

Oedipodinae. The oedipodines are inhabitants of the drier, temperate to tropical regions throughout the world. They are poorly represented in the Neotropical region (seven genera). All of these Neotropical representatives have clearly Nearctic affinities. The invasion of South America by the oedipodines must be very recent, maybe during the Pleistocene. The most common oedipodine species in South America belongs to the North American genus *Trimerotropis,* and, though several specific names are applied to it in different regions, it is probably a single species ranging from Colombia to southern Argentina and Chile, and is abundant from the Andean Altiplano to sea level under arid conditions. The other six genera are located in the northern part of South America, in Central America, and the West Indies.

FAUNAL STRATA IN THE ACRIDOMORPHS OF THE NEOTROPICAL REGION

The Neotropical acridomorph fauna, according to the above, seems to be grouped roughly into three different faunal strata.

The oldest of these strata is formed by the families Proscopiidae, Tristiridae, Ommexechidae, and Romaleidae. The family Pauliniidae should perhaps be added to the preceding unless it proves to be related to the Acrididae. These families seem to be autochthonous South American insects, that is, descendants of acridomorph or pre-acridomorph sotck already existing in the South American part of Gondwana prior to its breaking away from the rest of the Gondwanian lands. Their evolution and distribution centers are located in different parts of southern South America. Three different lineages seem to be represented among them (exclusive of the Pauliniidae). The oldest and most divergent from the rest of the acridomorphs are the Proscopiidae. They

are followed by the Tristiridae, which are less ancient and closer to the rest of the acridoids. The Ommexechidae and Romaleidae together represent the third lineage, more evolved and probably less ancient than the tristirids.

A second and probably more recent stratum is formed by a series of subfamilies of Acrididae which are exclusively Neotropical (though some have representatives in the south of the Nearctic region). They are the Proctolabinae, Copiocerinae, Leptysminae, Rhytidochrotinae, and Ommatolampinae. Their evolution and distribution centers are located in Central America and northern South America (Guiana Shield), and they have envaded, as a rule, the Amazon basin. All are composed of tropical species, only a few of these species having become established in subtropical or temperate regions. Considering that the family Acrididae, to which they belong, is widespread throughout the world, it may be postulated that these Neotropical subfamilies are the descendants of tropical acridids that came to, or were originally located in, the southern, tropical part of the North American continent. From there, these acridids invaded Central America when conditions after its emergence permitted, and later they migrated to South America, probably as waif emigrants, through island chains, in several invasions beginning in early Cenozoic times.

An alternate explanation that seems less plausible is that these acridids belong to a relatively ancient stock common to tropical Africa and northern South America. The Guiana Shield did not become separated from Africa until Lower Cretaceous times, being the last part of South America to lose contact with the African continent. In order to accept this theory, a considerable antiquity for the Acrididae as a family must be postulated, which seems unlikely. In this case, the nearest relatives of these Neotropical subfamilies of Acrididae in the recent fauna should be found in tropical Africa and, to my knowledge, they have not been located so far. The time elapsed from Lower Cretaceous times to the present (120-130 million years) seems long enough for considerable evolution to have taken place and, hence, relationships in recent forms would be difficult to locate.

To this group of acridid subfamilies belong most of the dendrophilous forms of the tropical jungle (Central America, Guianas, Amazon basin). The richess of this dendrophilous fauna suggests that these insects have undergone the same mechanism of speciation by isolation in "refuges" during the Pleistocene glaciations which has been described for other sectors of the Amazonian fauna (Haffer, 1967; Turner, 1975; Vanzolini & Williams, 1970; Vuilleumier, 1971).

A last and very heterogeneous stratum must be added to the preceding ones. The only common feature of the elements in this third stratum is that all of them seem to have invaded the Neotropical region in relatively recent times, and the South American part of it probably in late Cenozoic, about the time of the completion of the Panamanian land bridge in Mid-Pliocene or later. To this stratum belong the Eumastacidae, Pyrgomorphidae, and several of the subfamilies of the Acrididae, namely, the Melanoplinae, Acridinae, Gomphocerinae, and Oedipodinae. To these perhaps the Cyrtacanthacridinae should be added, but the time of their invasion of the Neotropical region seems difficult to estimate. Obviously, three different lineages are included in this stratum. A very old one is represented by the Eumastacidae; a relatively more modern but still ancient one by the Pyrgomorphidae; and a third one in which all the modern and more evolved lines of Neotropical Acrididae are put together.

Within this last stratum of relatively recent invaders, the eumastacids are tropical, the pyrgomorphids tropical and subtropical, while the included subfamilies of Acrididae are, in general, originally of temperate climates. Among these Acrididae of the neotropical fauna, different degrees of adaptation to tropical conditions can be discerned.

SUMMARY

Any attempt at interpretation of the origin, evolution, and distribution of the Neotropical acridomorph fauna was, until recently, practically impossible because of the very imperfect knowledge of their systematics. A number of recent works on the subject have clarified it to the point of making at least a preliminary hypothesis feasible.

Progress in the geophysical sciences during the last fifteen years, especially in the displacements of the continents after the close of the Paleozoic, has an important bearing on the history of the Neotropical region. Also, recent advances in the paleogeography, stratigraphy, and paleontology of this region substantially help our undestanding of the biota.

The recently acquired information on the effects of the Pleistocene glaciations on the South American continent and their influence on the climatic and vegetation zones and on the evolution and speciation of many Neotropical animal and plant groups cannot be ignored anymore in studies of the evolution and distribution of the Neotropical fauna.

Putting together all the mentioned elements, plus what is known of the past history, phylogeny, and systematic relationships of the acridomorphs themselves, a preliminary hypothesis is made on the origin, evolution, and distribution of the Neotropical fauna of these insects.

The Neotropical acridomorph fauna, according to this hypothesis, can be roughly divided into three strata, taking into account mainly their probable origin and history, their present distribution, and the assumed length of their presence in the Neotropical region.

The first of these strata is formed by the Proscopiidae, Tristiridae, Ommexechidae, and Romaleidae. They are postulated as the descendants of acridomorph or pre-acridomorph stock that was already in the South American part of Gondwana before it broke away from the rest of the lands of that supercontinent. Out of this common origin has arisen this evidently heterogeneous stratum. The proscopiids are probably much older and more primitive than the rest and also systematically removed from them. Of the three remaining families, the Tristiridae are the older group, the Ommexechidae-Romaleidae assemblage being far more evolved. To this same stratum, the family Pauliniidae, of uncertain affinities, should perhaps be added.

The second stratum, much more homogeneous than the other two, is formed by the five subfamilies of Acrididae that are exclusively Neotropical (Proctolabinae, Copiocerinae, Leytusminae, Rhytidochrotinae, and Ommatolampinae). Those subfamilies, as revealed by their present distribution, seem to have their evolution and distribution centers in Central America and the northern part of South America, whence they spread mainly to the Amazon basin and elsewhere in some cases. They are of tropical lineage, and may represent an early branch of the Acrididae that established in the southern or tropical part of the North American continent and that invaded, also at an early epoch, the northern part of South America. Or they may have descended from African-Guyanan acridid stock which remained in the Guiana Shield after its separation from Africa. But the last of these tentative explanations seems the less probable because it implies a considerable antiquity for this stock and relationships with the African fauna that have not yet been demostrated.

The third and most recent of the faunal strata is taxonomically and in terms of the origin of its elements heterogeneous. These elements, however, have in common evident relationships with the faunas of the rest of the world. For this reason they are put together as the most recent elements of the acridomorph fauna of the neotropical region, which they must have reached in relatively modern times. As for the South American part of this region, must of them seem to have invaded it during the Late Cenozoic (Pliocene and post-Pliocene) times. In this stratum are included the very ancient group of the eumastacids, the more recent one of the pyrgomorphids, and the remaining subfamilies of the Acrididae (Melanoplinae, Cyrtacanthacridinae, Acridinae, Gomphocerinae, and Oedipodinae), which are more evolved than the proceding families.

RESUMEN

Una interpretación del origen, la evolución y la zoogeografía de la fauna neotropical de acridomorfos, resultaba prácticamente imposible hasta hace muy poco tiempo, a causa de un conocimiento muy imperfecto de su sistemática. Un cierto número de trabajos recientes sobre este tema lo han clarificado considerablemente, hasta el punto de hacer posible por lo menos una hipótesis preliminar.

El progreso de los conocimientos geofísicos en los últimos quince años, especialmente en lo que se relaciona con la deriva continental después del paleozoico, es asimismo de gran utilidad para comprender la distribución de las faunas pasadas o actuales, y tiene gran significación para la historia de la región neotropical. Asimismo, el progreso reciente de la paleogeografía, estratigrafía y paleontología de esta región, contribuyen en forma substancial a nuestro conocimiento de su biota.

La información obtenida en los últimos años, sobre los efectos de las glaciaciones del pleistoceno en el continente sudamericano, y su influencia sobre las zonas climáticas y formaciones vegetales y, en consecuencia, sobre la evolución y especiación de muchos grupos de animales y plantas neotropicales, no puede ser ignorada de ahora en adelante en futuros estudios sobre la evolución de la fauna neotropical.

Reuniendo todos los elementos mencionados y la información disponible sobre la historia, filogenia y afinidades de los acridomorfos, se ha formulado una hipótesis preliminar sobre el origen, evolución y distribución geográfica de la fauna neotropical de estos insectos.

La fauna neotropical de acridomorfos, de acuerdo a esta hipótesis, puede ser dividida, a grandes rasgos, en tres estratos faunísticos, de acuerdo principalmente a su origen probable, su historia, su distribución geográfica actual, y el tiempo estimado de su presencia en la región neotropical.

El primero y más antiguo de estos estratos estaría formado por las familias Proscopiidae, Tristiridae, Ommexechidae y Romaleidae. Se postula para estas familias su descendencia de antepasados acridomorfos o pre-acridomorfos que ya estaban presentes en la parte sudamericana de Gondwana, antes de que se separara del resto de las tierras de dicho supercontinente. Fuera de esta supuesta comunidad de origen territorial, este estrato es evidentemente heterogéneo. Los proscópidos son verosimilmente más antiguos y primitivos que el resto, y están asimismo alejados de los demás desde el punto de vista taxonómico. De las familias restantes, Tristiridae es la más antigua; el conjunto Ommexechidae-Romaleidae es más evolucionado. A este estrato quizá deba agregarse Pauliinidae, de afinidades inciertas.

El segundo estrato, mucho más homogeneo que los otros dos, está formado por las cinco subfamilias de Acrididae (Proctolabinae, Copiocerinae, Leptysminae, Rhytidochrotinae y Ommatolampinae) que son exclusivamente neotropicales. Estas subfamilias, tal como lo revela su distribución actual, deben haber tenido sus centros evolutivos y de distribución en América Central y la parte norte de la América del Sur (Escudo Guayanense), desde donde se dispersaron principalmente a la cuenca amazónica, y en algunos casos también a otras regiones. Todos estos acridios son de clima tropical, y podrían representar una línea primitiva de Acrididae, establecida tempranamente en la parte meridional de la América del Norte, y restringida al principio a esta zona por razones climáticas. Estos insectos invadieron muy pronto la parte septentrional de la América del Sur. Otra posible alternativa es la de que estos insectos desciendan de una línea de acridios afro-guayanense, que quedó en la parte septentrional de América del Sur cuando su separación del Africa. Pero esta última explicación parece la menos probable, ya que implica una considerable antiguedad de esta línea de Acrididae, y relaciones con la fauna africana que no han sido encontradas aún.

El tercero y mas reciente de los estratos faunísticos es, desde el punto de vista taxonómico, y también en lo relacionado con el origen de sus elementos, el más heterogéneo. Estos elementos que lo forman sin embargo, tienen en común las características de su evidente relación con las faunas del resto del mundo, y de representar además la parte mas reciente de la fauna de acridomorfos de la región neotropical, a la cual deben haber llegado, en su mayor parte, en época relativamente moderna. En lo que concierne a la parte sudamericana de dicha región, la mayoría de los elementos de este estrato deben haber llegado a ella a fines del cenozoico (plioceno y posteriormente). En este estrato se reúnen el grupo arcaico de los Eumastacidae, los Pyrgomorphidae que son seguramente mas recientes, y las subfamilias de Acrididae que no han sido incluidas en el estrato anterior (Melanoplinae, Cyrtacanthacridinae, Acridinae, Gomphocerinae y Oedipodinae) mucho más evolucionadas en su onjunto que las mencionadas anteriormente.

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